METAL PROGRESS

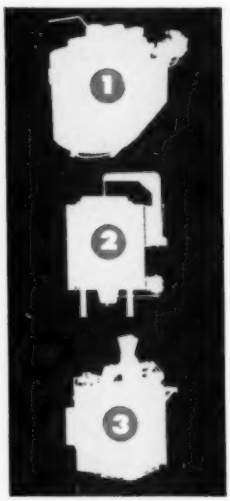
OCTOBER 1949

3 New INDUSTRIAL FURNACES

Engineered by 'Surface' for GREATER ECONOMY OF PRODUCTION

Surface Combustion Heating and Heat Treating Furnaces always have been engineered for the utmost economy of production. This means the most efficient furnace design and operating characteristics for the specific job . . . whether the requirements were for standard rated units or special continuous production types.

Now, three new furnace units are to be introduced to provide the heat treater with even greater flexibility and economy in operation. These units meet current needs and demands for efficiency in operation, labor saving, with minimum space and maintenance.



1 **'Surface' Forc-Aire Furnace** . . employs convection heating at its greatest efficiency. A new standard design embodying proved combustion principles with modern features to meet today's requirements for highly efficient furnace operation. *Unit on display at 'Surface' booth.*

2 **'Surface' Atmotrol Furnace** . . a new standard design unit of the vertical muffle type for batch heat treating. Can be used with any prepared gas atmosphere for all modern heat treating processes. Provides extreme flexibility in operation. *Unit on display at 'Surface' booth.*

3 **'Surface' Batch-type, Atmosphere Furnace** . . high-capacity, radiant tube heated furnace with built-in prepared gas atmosphere generator. Also equipped with vestibule for charging and slow cooling, and a lowerator mechanism and tank for liquid quenching. Especially adaptable to gas carburizing, carbon restoration (skin recovery), dry cyaniding, homogeneous carburization, clean hardening, and for general heat treating.

and in addition . . .

HOMOGENEOUS CARBURIZATION . . . a process whereby fabricated metal parts of thin section made from low carbon steel, can be heat treated in an atmosphere to transform the metal to a medium or high carbon steel, as desired.

GET ALL THE PARTICULARS AT 'Surface'

Welcome

TO 'SURFACE' HEAT TREAT HEADQUARTERS

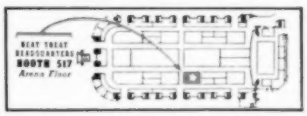
BOOTH 517

Arena Floor

NATIONAL METAL EXPOSITION

● For the 30th year, Surface Combustion will bring new innovations in heat treating processes and equipment to visitors at the National Metal Exposition.

The 'Surface' booth located in the main arena of the Public Auditorium, Cleveland, will be larger in floor space and there will be displayed three new furnace units designed to give *greater economy of production.*



'Surface' Industrial Furnace Engineers will be available at all times to answer questions and explain the many heat treating processes that have been developed in the 'Surface' research laboratory in Toledo, Ohio.

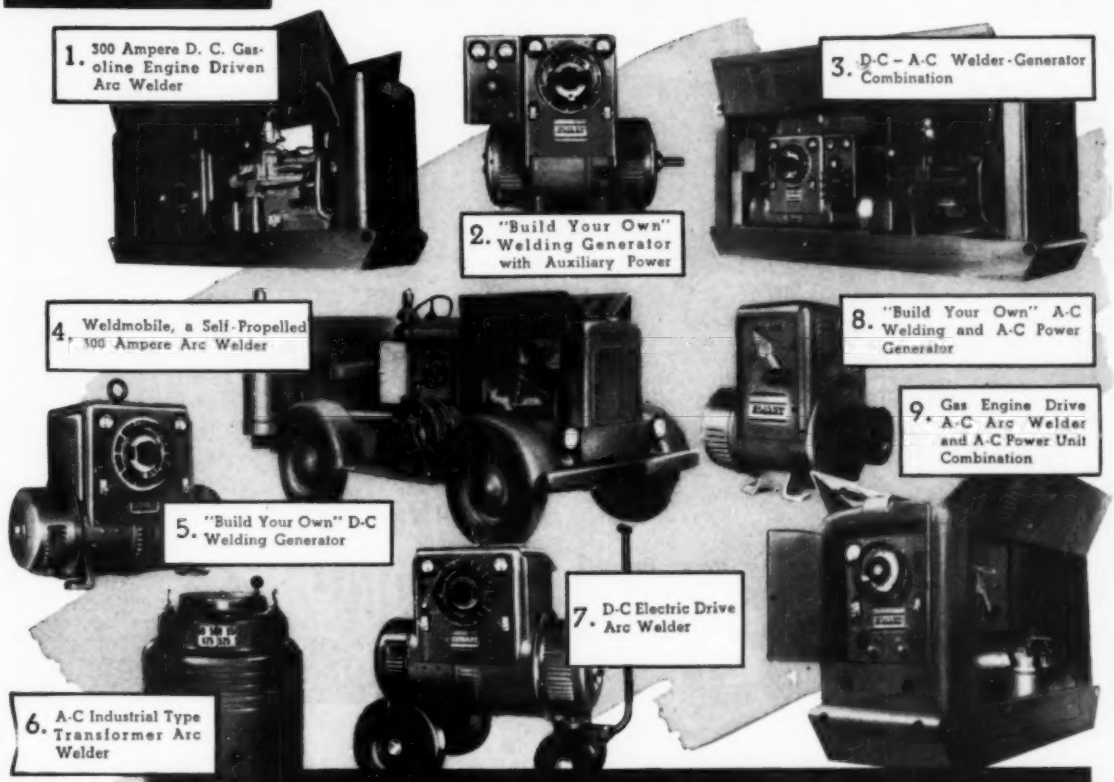
Complete descriptive and specification literature on special furnaces, standard rated furnaces, industrial burners, special gas atmosphere generators and special heat treat processes will be available to all who visit the show. The processes include gas carburizing, suspended carburization, carbon restoration (skin recovery), homogeneous carburization, clean and bright atmosphere hardening, dry (gas) cyaniding, bright super-fast gas quenching, atmosphere malleableizing, atmosphere heating for forging and high speed billet heating.

'Surface' cordially invites you to "heat treat headquarters" at the National Metal Exposition.

BOOTH 517
Arena Floor
Cleveland Public Auditorium
NATIONAL METAL EXPOSITION
October 17 through 21

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

HOBART "one of the world's largest builders of arc welders"


1. 300 Ampere D. C. Gasoline Engine Driven Arc Welder
2. "Build Your Own" Welding Generator with Auxiliary Power
3. D-C – A-C Welder-Generator Combination
4. Weldmobile, a Self-Propelled 300 Ampere Arc Welder
5. "Build Your Own" D-C Welding Generator
6. A-C Industrial Type Transformer Arc Welder
7. D-C Electric Drive Arc Welder
8. "Build Your Own" A-C Welding and A-C Power Generator
9. Gas Engine Drive A-C Arc Welder and A-C Power Unit Combination

One of these HOBART WELDERS is a "must" for you . . . if you want lower costs . . . faster production

Better Welds with Hobart Electrodes

The new Hobart No. 12 lets you use higher welding currents with less clean-up time due to exceptionally low spatter loss. Write for samples today.

• AT THE NATIONAL METAL EXPOSITION

See the HOBART Arc Welders, Electrodes and Accessories on display at Booth No. 2544.

A. C. or D. C. . . . there is a right size HOBART Arc Welder ready to cut costs on all your jobs, large or small. Longer lived . . . lower in cost . . . easier to use. Get the new Hobart Welder Catalog. You'll see why it pays.

HOBART WELDERS

It's Better to have bought a *HOBART* than wish you had

Electrode Catalog Free!

Gives data on full range of Hobart Electrodes made in all sizes for A.C. and D.C. welding. Check and mail coupon today.

HOBART BROTHERS COMPANY, Box MM-109, Troy, Ohio

Please send without obligation ( ) Catalog showing complete line of HOBART Arc Welders, ( ) Catalog on HOBART Electrodes.

Our work is.....

Tell us more about HOBART Arc Welders of ..... amp. capacity, driven by ..... Check here for special data on machines numbered above .....1 .....2 .....3 .....4 .....5 .....6 .....7 .....8 9

Name.....

Position.....

Firm.....

Address.....

LATROBE DESEGATIZED

BRAND

HIGH SPEED STEELS

●

HIGH CARBON – HIGH CHROMIUM DIE STEELS

LATROBE DESEGATIZED* BRAND STEELS cut heat treating losses by responding advantageously to heat treating processes. This desirable response is the direct result of FULL UNIFORMITY . . . that is, steel in which the all-important carbide particles are evenly dispersed throughout. This exclusive feature of LATROBE DESEGATIZED BRAND STEELS eliminates unnecessary structural stresses: cracks, checks and warpage are radically minimized . . . more freedom in design of parts is allowed . . . . ease of machining and grinding, and increased tool and die life are resultant.

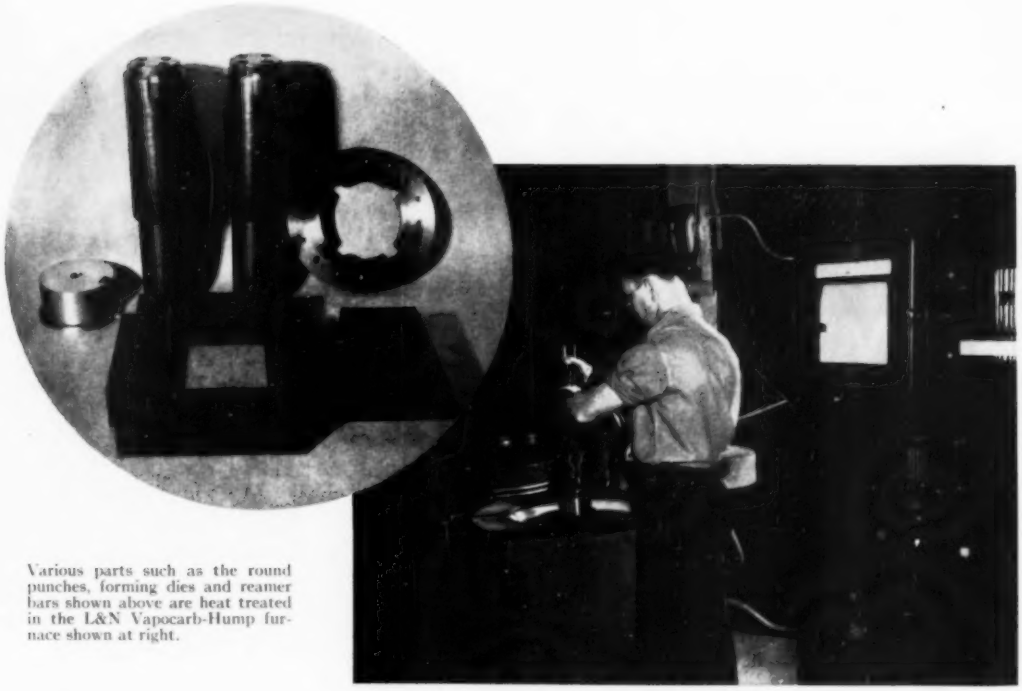
LATROBE DESEGATIZED STEELS
Setting the Pace
in Tool Steel Quality!

*Trade Mark Registered U. S. Pat. Office

LATROBE ELECTRIC STEEL COMPANY

LATROBE, PENNSYLVANIA

Write or call your nearest Latrobe Sales Engineer for the complete facts on LATROBE DESEGATIZED BRAND STEELS.
Branch Offices and Warehouses are conveniently located in principal cities.



Various parts such as the round punches, forming dies and reamer bars shown above are heat treated in the L&N Vapocarb-Hump furnace shown at right.

TOOLING UP?

Vapocarb-Hump method helps harden . . accurately

About six years ago, Reliance Electric & Engineering Co., of Cleveland, Ohio, decided to install their own heat treating department. This was done to assure greater control over the production of punching dies and machine tools. Naturally, they wanted to obtain fast, quality, uniform production . . . production their heat treaters could duplicate at any time. As a result of these requirements, Reliance chose L&N's Vapocarb-Hump method for hardening as the equipment that would best meet their needs.

Dies are used for making rotor and stator laminations of electric motors. A wide variety of steels are employed, ranging from minimum shrink die steel to open hearth types. Quench may be by water, oil, or a light fan blast.

Reliance Electric has been operating its Vapocarb-Hump equipment for 16 hours a day since it was installed. During that time, the method has provided continuous, dependable production. In addition, tool distortion has been practically eliminated. For example, in a typical armature die, made of oil hardening steel, symmetrical, with an 8″ OD and 5″ ID, dimensional changes are held to only 0.0015″.

The Vapocarb-Hump method is a completely integrated process for hardening. With this equipment, all of the factors affecting the hardening are under the control of the heat treater at all times. This means that the heat treater can regulate the furnace atmosphere, the rate of heating, and the quench. Since these controlling factors can be duplicated time and time again, the result is consistent, predictable, quality work.

We will be glad to supply further information about this reliable, time tested, heat treating method. Just write to Leeds & Northrup Co., 4927 Stenton Avenue, Philadelphia 44, Pennsylvania.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl. Ad TB2-621(1)

Metal Progress is published and copyrighted, 1949, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879.

Now--More KW-at with New-Design

MOST brazing, soldering, heat-treating and heating for forging operations can be performed at lower *unit* cost with TOCCO Induction Heating. Now with the introduction of new design TOCCO machines the *initial* cost of induction heating equipment—the capital outlay per kilowatt—is *greatly reduced*. So now, more than ever before, it pays you to have a TOCCO engineer survey your plant to determine where TOCCO Induction Heating can help you speed production and cut costs. It doesn't cost you a cent and may save you a great deal.

New vertical design of TOCCO high-frequency motor-generator sets takes less floor space. They're lighter, too, for easy handling and installation in your plant. New TOCCO units have heat exchanger type water-cooling plus thermal protection against over-heating of bearings, generator and motor. (Available in 2 sizes: 250 KW output at 10,000 cps; 300 KW output at 3,000 cps.) One TOCCO motor-generator set provides high-frequency power to TOCCO heating stations spotted at convenient production-line locations throughout your plant.

For Better Products, Faster, at Lower Cost

Much Lower Cost

TOCCO* Induction Heating Equipment

Any Number of Heating Stations --Any Place in Your Plant

New design TOCCO heating stations can be located anywhere in your plant—handy to related operations. They're complete units in themselves with all necessary controls right at the heating station. Operate one or a dozen separately or at the same time—from one TOCCO high-frequency power source.

Picture of accessibility! Timers, condensers, transformers, contactors—all electrical elements at your fingertips. Interlock kills power when door is opened—a valuable safety feature. In multiple station operation only one "Master Station"—i.e., a station complete with meters and generator controls—is required.

BOOTH No. 537—METAL SHOW

Cleveland, October 17—21. See the new TOCCO machines. Also learn how you may win $1000 in TOCCO's "Economy In Production" Contest!

TOCCO

Mail Coupon Today

FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. R-10, Cleveland 1, Ohio

Please send copy of 48-page bulletin "TOCCO Induction Heating"

Name_____

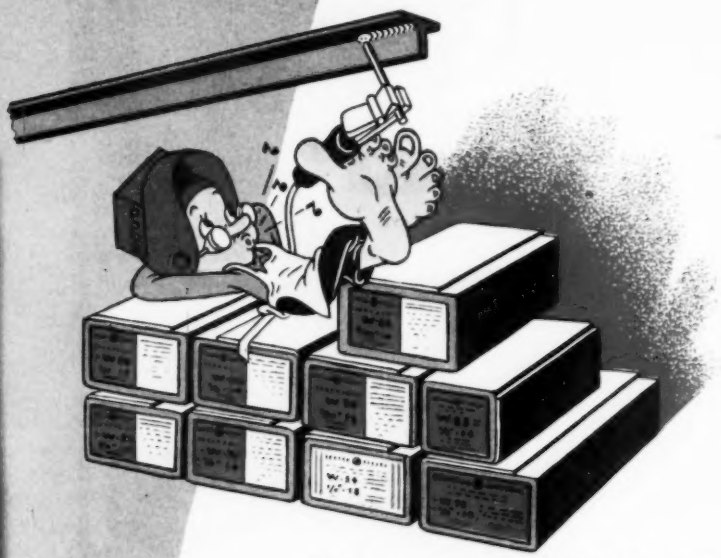
Position_____

Company_____

Address_____

City_____ Zone____ State_____

it's So Easy when



Hey, Joe MaGee! We know it's easy to make good welds with G-E electrodes—but we don't quite recommend welding with your toes! At any rate, you'd better pull that headshield down before striking the arc.

You'll have to forgive Joe, folks, he's so enthusiastic about G-E electrodes, he's ready to go to 'most any lengths to demonstrate how easy they are to use—and get better welds in the bargain! Joe knows he can depend upon every one of the 70 types of G-E electrodes, because rigid usability tests assure maximum quality and quantity of deposit. To pass these tests, G-E electrodes must offer the best type of stable arc transfer, proper contour of deposit, ease of slag removal, low spatter loss, and excellent appearance of the finished weld.

HERE'S WHAT USERS FIND . . .

Joe MaGee is not alone in his enthusiasm for G-E rods. Here's just one example . . . the Peshastin Lumber and Box Co. of Peshastin, Washington, felt completely satisfied with the electrodes they were using and saw no reason for changing. However, after trying a sample of G-E W-25 electrode, they promptly placed an order for their production requirements, and have been a constant user of G-E electrodes ever since.

Yes, the proof of the electrode is in the welding. Your G-E Arc-welding Distributor will be glad to supply you with electrode samples—in fact, to service *all* of your arc-welding requirements. And in the meantime, why not clip and mail the coupon for a copy of our handy new, pocket-size electrode catalog and manual, GEC-482.

HAVE YOU SEEN "ARC WELDING AT WORK"? It's a 30-minute, sound motion picture in color—major component of General Electric's *More Power to America* program on Electric Arc Welding. The film and accompanying literature point out clearly the design and production advantages inherent in the three major types of arc welding—metal-arc, Inert-Arc, and atomic-hydrogen. Your G-E Arc-welding Distributor will arrange a showing for you.

Joe MaGee
Sect. H673-71
Apparatus Department
General Electric Company
Schenectady 5, N. Y.

☐ Send me one of your new electrode catalog-manuals (GEC-482), Joe—pocket-sized for handy reference.
☐ Yes, I'd like to see "Arc Welding at Work."

Name .....

Company .....

Address .....

City ..... State .....

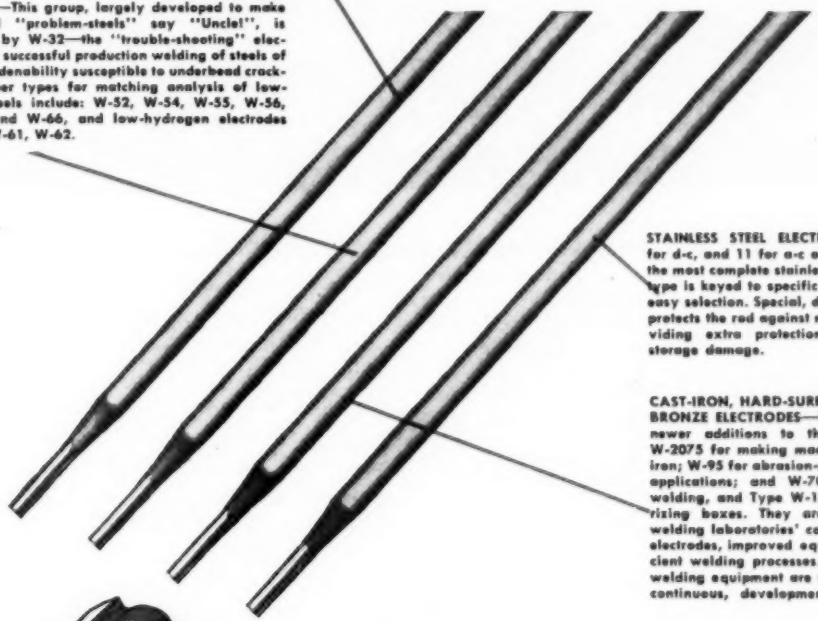
you use...

ARC-WELDING ELECTRODES

The 70 odd varieties of G-E electrodes, each developed for a specific application or type of welding, may be classified into four major categories. Whether you're welding mild steel, stainless or other alloys . . . horizontal, vertical, or overhead . . . a-c or d-c . . . you'll likely find a G-E electrode that will help you *cut costs* on the very job you're doing.

MILD-STEEL AND GENERAL-PURPOSE ELECTRODES—This group of 7 types is headed by W-28, a general-purpose, all-position rod with an unusually stable arc that produces welds of superior appearance, at high speeds, with minimum convexity. Other electrodes in this group are available specifically for horizontal, vertical, or overhead welding, etc.

SPECIAL-PURPOSE AND LOW-HYDROGEN ELECTRODES—This group, largely developed to make so-called "problem-steels" say "Uncle!", is typified by W-32—the "trouble-shooting" electrode for successful production welding of steels of high-hardenability susceptible to underbead cracking. Other types for matching analysis of low-alloy steels include: W-52, W-54, W-55, W-56, W-58, and W-66, and low-hydrogen electrodes W-60, W-61, W-62.



STAINLESS STEEL ELECTRODES—29 types (18 for d-c, and 11 for a-c or d-c) make this one of the most complete stainless lines available. Each type is keyed to specific AISI code numbers for easy selection. Special, double-carton packaging protects the rod against moisture as well as providing extra protection against transit and storage damage.

CAST-IRON, HARD-SURFACING, & PHOSPHOR-BRONZE ELECTRODES—Herein are some of the newer additions to the G-E electrode line; W-2075 for making machinable welds on cast-iron; W-95 for abrasion-resistant, hard-surfacing applications; and W-70 for phosphor-bronze welding, and Type W-1331 for welding carburizing boxes. They are exemplary of G.E.'s welding laboratories' constant search for better electrodes, improved equipment, and more efficient welding processes. You users of G-E arc-welding equipment are the beneficiaries of this continuous, developmental research program.

Copyright 1948, General Electric Co.

"A-C or D-C . . . there's G-E Arc-welding Equipment for Every Application!"

ARC WELDERS • ELECTRODES • ACCESSORIES

GENERAL ELECTRIC

WHICH CARBURIZING BOX
Cut Fuel Costs $40 a Heat?

The above is not a case of trick photography. Only the PSC carburizing box is pictured because considerations of propriety made it advisable to omit a photo of one of the old cast boxes which were replaced at such a saving. In addition to lowering the fuel costs, the installation of PSC sheet alloy carburizing boxes also effected substantial labor savings, because they handle easier and faster due to their lighter weight.

Weigh Up to 2/3 Less. Save Time and Fuel

This installation graphically illustrates the fuel economies which PSC carburizing boxes effect. To heat the metal itself of the old cast boxes was costing $60 a furnace cycle. Since the PSC sheet alloy boxes weigh 2/3 less a loading of them could be heated for roughly $40 less. This sizable saving, multiplied by the number of heats in a year, developed into a real slash in production costs for the department. Today 80% of the nation's heat treaters use PSC carburizing boxes. Plant records show they last 2 to 20 times longer. As pioneers of light-weight sheet alloy heat treating equipment, we offer you a wealth of experienced engineering assistance. PSC units are furnished in any size, design or metal specification, and for every purpose: annealing and carburizing boxes, covers, baskets, racks, tubes, retorts, etc. Send blue prints or write as to your needs.

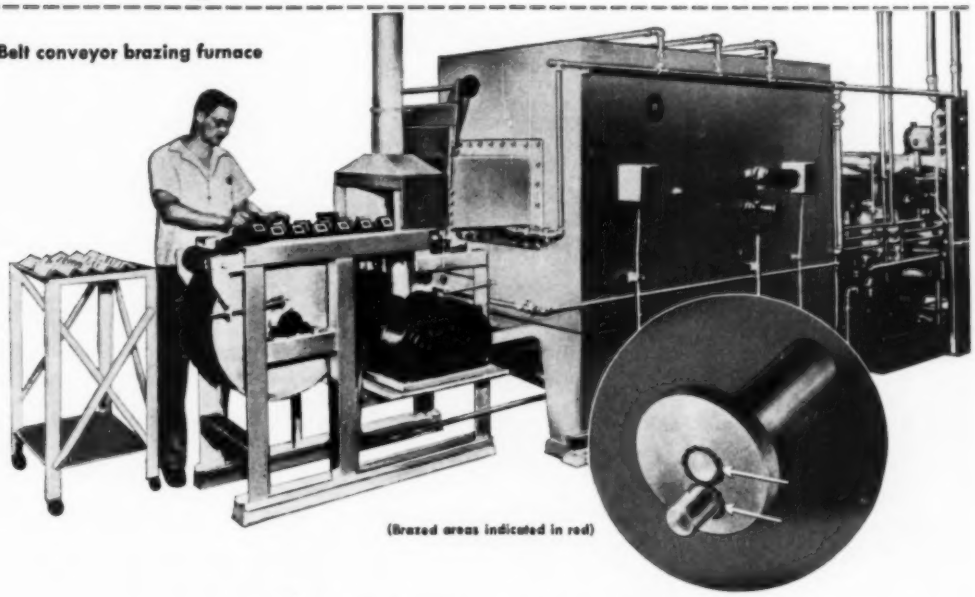
THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆

YOU CAN BE **SURE**.. IF IT'S

Westinghouse



Belt conveyor brazing furnace

(Brazed areas indicated in red)

$1,120 SAVED

every 8 working hours with Westinghouse Brazing

Four cents per unit! $1,120 every eight hours. That's what one manufacturer saved when he switched from machining to Westinghouse brazing. With production of 3,500 units per hour, each furnace produced these startling savings.

Why spend dollars? Braze it for pennies with Westinghouse equipment. The Westinghouse brazing furnace is only one of a wide variety of furnaces—both gas-fired and electric—produced by Westinghouse.

For either gas-fired or electric operation, Westinghouse can make thorough, impartial recommendations for the type of equipment needed to handle your heat-treating problem most economically. Get all the facts today. Call your nearest Westinghouse office or write Westinghouse Electric Corporation, 181 Mercer Street, Meadville, Pennsylvania. J-16347

Therm-a-neering. **A HEAT AND METALLURGICAL SERVICE THAT OFFERS WITHOUT OBLIGATION:**

ENGINEERS—Thermal, design and metallurgical engineers to help you study your heat-treating problems with a view toward recommending specific heat-treating furnaces and atmospheres.

RESEARCH—A well-equipped metallurgical laboratory in which to run test samples to demonstrate the finish, hardness, and metallurgical results that can be expected on a production basis.

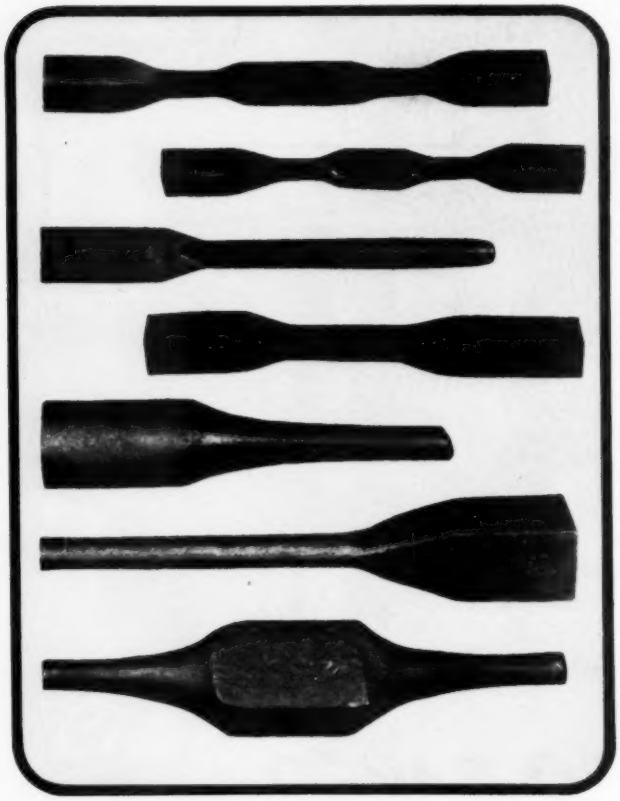
PRODUCTION—A modern plant devoted entirely to industrial heating.

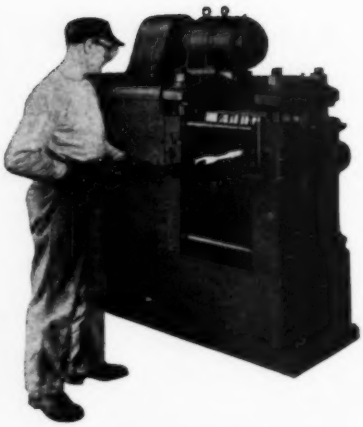
EXPERIENCE—Manufacturers of a wide variety of furnaces—both gas and electric—and protective atmosphere generators.

Westinghouse

GAS AND ELECTRIC

Furnaces





AJAX ROLLS

For all sizes and types of FORGING BLANKS

Available in six sizes, AJAX Wide Adjustment Forging Rolls have capacities for pre-rolling forging blanks ranging from the smallest automobile valve rocker arm to the largest airplane propeller. And backing these, AJAX engineers have a priceless wealth of experience in design of roll grooves and pre-rolled forging blanks acquired during the more than fifty years since AJAX introduced these Rolls into the forge shop.

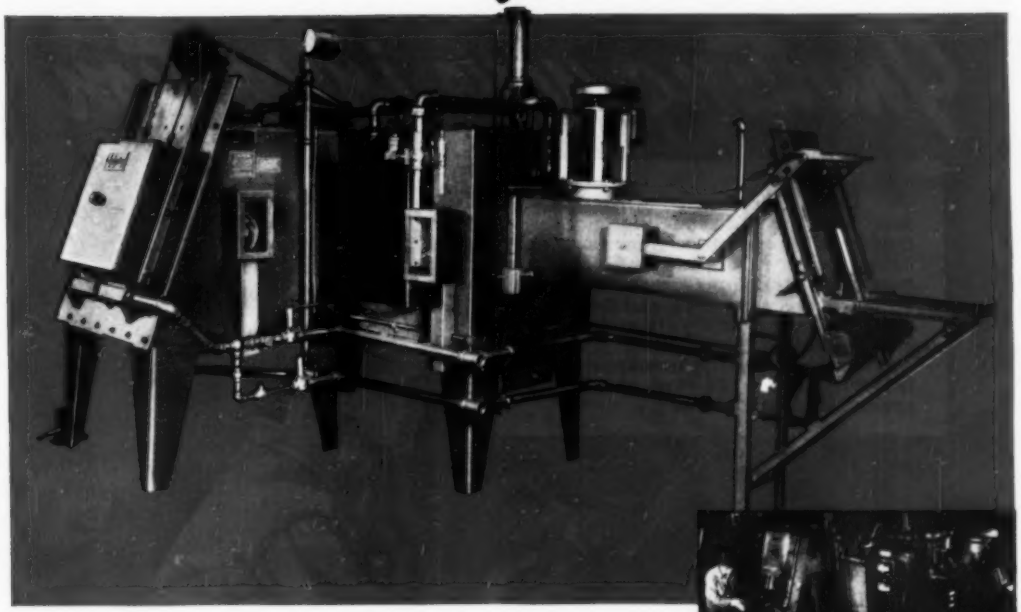
Die width to accommodate the considerable series of grooves required for abnormally great, cross-sectional reductions or several groups of grooves for blanks with different metal distribution, gives these machines wide general utility.

The advantages accruing in the press forging or drop forging of accurately proportioned, pre-rolled blanks through metal saving, longer die life, greater output and stronger forgings warrant your investigation.

WRITE FOR AJAX BULLETIN 91-A
And Additional Information

THE AJAX MANUFACTURING COMPANY
EUCLID BRANCH P. O. CLEVELAND 17, OHIO
110 S. DEARBORN ST. CHICAGO 3, ILLINOIS
DEWART BUILDING NEW LONDON, CONN.

Announcing a new process for heat treating High-Speed Steels!



THE LINDBERG "L-TYPE" FURNACE

This revolutionary new furnace is designed to harden precision high-speed tools completely scale free and without discoloration. It is ideal for tools with fine cutting edges that cannot be ground or cleaned after hardening.

Unique in construction and appearance—preheat, high heat and quench are combined in one unit—designed for complete atmosphere protection from start to finish. The "L-Type" Furnace is the result of three years of research and a year and a half of testing in the Lindberg Commercial Heat Treating Plants. It is the FIRST MAJOR ADVANCE in hardening high-speed steels since the introduction of atmosphere treating.

COMPLETELY ELIMINATES

- . . . cracking of tools due to quenching strains
- . . . removing scale by sandblasting or grinding
- . . . drastic dimensional changes during processing
- . . . oil quench tank and oil cooling system
- . . . washing quench oil from work
- . . . decarburization and carburization troubles

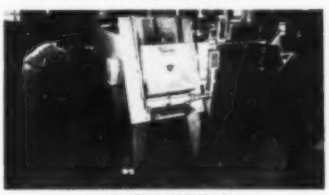
OFFERS MANY ADVANTAGES

Improved surface appearance... Increased tool life... Decreased heating costs... Decreased atmosphere costs... Improved working conditions... Not limited to high speed steels.

Write for Bulletin No. 220 for full details.

LOS ANGELES, CALIFORNIA

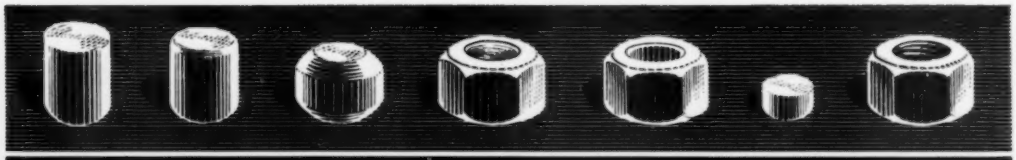
ST. LOUIS, MISSOURI



CHICAGO, ILLINOIS

LINDBERG ENGINEERING COMPANY 2448 W. Hubbard Street, Chicago 12, Illinois

LINDBERG FURNACES



Inviting your inspection

BECAUSE Youngstown "Scrapless" Nut Wire is designed for modern cold-heading operations, it invites your critical tests. You'll find its sizing accurate and its composition correct. It measures up on chemical and metallurgical checks for analysis and microexaminations.

Available in various compositions, including AISI standard as well as special sulphurized steels.

QUALITY YOUNGSTOWN SERVICE

Youngstown

"SCRAPLESS" NUT WIRE

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Manufacturers of Carbon, Alloy and Yoloy Steel

General Offices — Youngstown 1, Ohio

Export Office - 500 Fifth Avenue, New York

WIRE - COLD FINISHED CARBON AND ALLOY BARS - PIPE AND TUBULAR PRODUCTS - CONDUIT - RODS - SHEETS - PLATES - BARS - ELECTROLYTIC TIN PLATE - COKE TIN PLATE - RAILROAD TRACK SPIKES.

HEVI DUTY

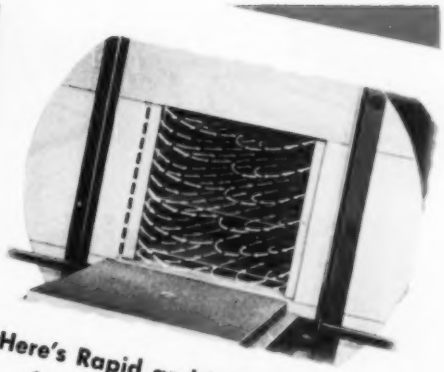
Announces a New

LABORATORY

AIR DRAW

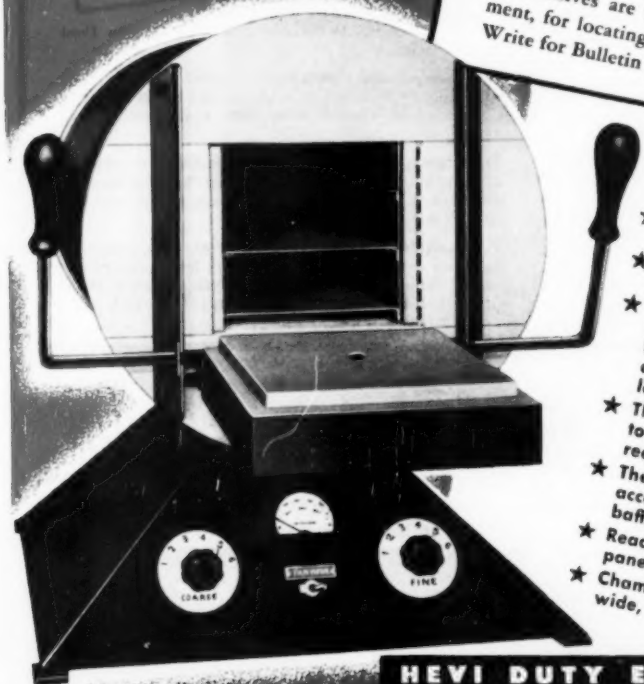
MUFFLE FURNACE

With many Special Advantages



Here's Rapid and Uniform Heating for any Operation Requiring Temperatures to 1250°F.

A high speed centrifugal fan is located at the rear of the heating chamber. A heat-resistant alloy baffle is provided to direct the flow of air from the fan through a narrow passage between the heating elements and the baffle, then into the work chamber, and back to the intake fan. Positive, high speed circulation of air throughout the furnace chamber is assured giving rapid uniform heating of the work. Two alloy, adjustable shelves are furnished, as standard equipment, for locating the work at different levels. Write for Bulletin LAB-1049.



The 0771-A Multiple Unit Air Draw Muffle Furnace Offers These Advantages:

- ★ Positive high speed circulation resulting in rapid, uniform heating.
- ★ Simplicity of design. Self contained instruments.
- ★ The alloy baffle may be removed easily by pulling it from the chamber. No bolts or fastening devices are required to keep it in its proper location.
- ★ The fan shaft is directly connected to the moter. No couplings are required.
- ★ The heating elements are readily accessible by removing the alloy baffle.
- ★ Ready access to instruments and panel board.
- ★ Chamber Dimensions—7" high, 7" wide, 12" deep.

TYPE 0771-A

HEVI DUTY ELECTRIC COMPANY

LABORATORY FURNACES **MULTIPLE UNIT** ELECTRIC EXCLUSIVELY

MILWAUKEE 1, WISCONSIN

with Du Pont

ACCELERATED SALT WS

The Free-Washing Liquid Carburizer

ONE BATH FOR CYANIDING AND LIQUID CARBURIZING

Check these 9 outstanding Advantages

1. **Free washing**—The salts composing this bath and their decomposition products are completely water soluble. Even detergents that may be used in cleaning oil-quenched work do not precipitate water insolubles with Du Pont Accelerated Salt WS.

2. **Excellent carburizing activity**—over a wide operating temperature range (1500°—1650°F.).

3. **Ball-out eliminated**—The high cyanide content of Accelerated Salt WS (66% NaCN, minimum) will maintain the average bath at operating strength by simply diminishing drag-out losses.

4. **Excellent fluidity**—A minimum of salt dragged out on the treated work.

5. **Low molten density**—Less salt for the initial charge and reduced fresh salt replenishments as compared to the barium-activated salt baths.

6. **Minimum heat radiation losses and fuming**—with the floating graphite cover. For the convenience of the operator, graphite is incorporated into the Du Pont Accelerated Salt WS mixture.

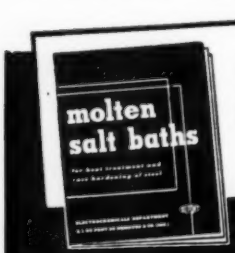
7. **Easy-to-handle pellets**—uniformly sized weighing approximately one ounce. A minimum of dust to annoy the operators when making bath replenishment additions.

8. **No sludge formation**—from infusible salt residues. All salts in the Du Pont Accelerated Salt WS mixture and their decomposition products form an homogenous melt at operating temperature.

9. **Simple bath control**—A single replenishment will maintain activity for at least twenty-four hours at operating temperature. Cyanide analysis, which is rapid and simple, is the only chemical control required.

For further information on Du Pont Accelerated Salt WS, or for experienced advice and technical assistance in selection and application of Du Pont heat treating materials, write or call our nearest district office. E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

DISTRICT OFFICES: Baltimore, Boston, Charlotte, Chicago, Cincinnati, Cleveland, Detroit, El Monte (Calif.), New York, Philadelphia, Pittsburgh, San Francisco.



FREE MANUAL ON MOLTEN SALT BATHS

More than 70 pages of practical material on heat treatment, fully illustrated. Ask for your copy.

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DU PONT CYANIDES and SALTS *for Steel Treating*

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NATIONAL METAL SHOW

Cleveland, October 17-21

• Art LaMasters—Frank Staral—Arnold Moore—Frank Faery—Bert Sutherland — Walter Johnson — William Davis — George Rogers will again be on hand to welcome you to our annual exhibit at the National Metal Show . . . . Drop by and have them tell you about the process that provides (for the first time) GRAIN SIZE CONTROL in Heat and Corrosion Resistant Castings . . . . They can also reveal information on the results of several years of Experimental and Research Development Work devoted to the Metallurgical improvement of "hot" components for Jet and Turbine Engines.

HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

ALLOY ENGINEERING AND CASTING COMPANY

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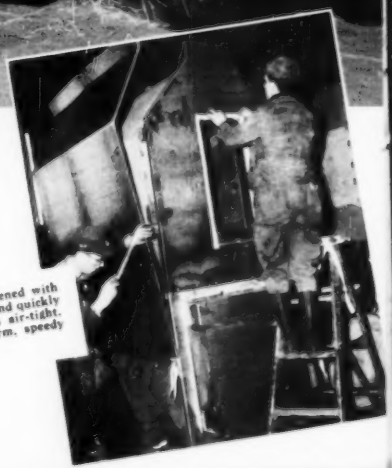
Champaign, Illinois

ENGINEERING IS PHILOSOPHY . . . GOOD ENGINEERING, PURE LOGIC

Who said it costs more to use Stainless Steel?

FAMOUS DRAVO USES STAINLESS

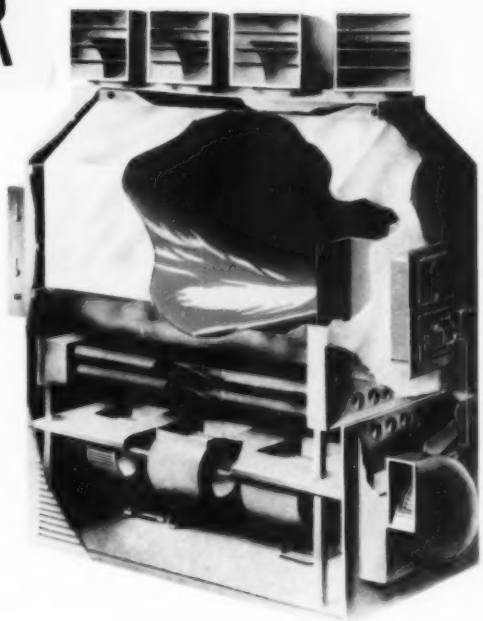
(Above) The Stainless Steel combustion chamber —the "heart of the heater"—takes finished shape. Note the simplicity of construction. Outer seams are continuous-welded, inside seams are intermittent. *(At left)* The completed Stainless chamber goes into the frame as a unit.



(At right) Outer casting goes on. Fastened with sheet metal screws, panels can be easily and quickly removed. Asbestos gaskets make joints air-tight. Mass production methods insure uniform, speedy manufacture.

Counterflo HEATER

TO REDUCE COSTS!



Completely self-contained, automatic in operation, this direct-fired heater provides an entirely new solution to the troublesome problem of plant heating. A "single-package" heating unit that can be positioned anywhere, it supplies heat directly to the area needing it, efficiently and economically.

Incidentally, it also proves that using Stainless Steel does not necessarily increase cost, but on the contrary, can decrease it.

THE heart of any heater is the combustion chamber. In the original Dravo Heater sold by the thousands to army camps and plants during the war, this chamber was made of corrugated carbon steel lined with refractory cement. Numerous fins and deflectors were welded to its outer surface.

To meet the tremendous civilian demand created by its highly successful war-time service, Dravo engineers recently redesigned the heater to increase its efficiency, to reduce its size and weight, to increase its life span, to make its operation safer. And in order to maintain prices in the face of rising labor and material costs, they took steps to speed up its production and to reduce manufacturing costs. They accomplished these things mainly by building the combustion chamber of Stainless Steel.

By specifying Stainless Steel that withstands temperatures up to 1600° F. they got rid of the troublesome and maintenance-demanding refractory lining. The unlined chamber, with its entire surface now exposed to the flame and gases, greatly increased heat transfer. This made it possible to eliminate fins and deflectors, allowed them to build the chamber smaller (to reduce its heating surface 53% without reducing operational performance) . . . and to reduce its weight 1500 pounds.

In addition, the simplified chamber design obtained by the use of Stainless Steel reduced the number of fabricating operations from 95 to 67. And, even though welding with Stainless requires more care, welding costs too were reduced because only 186 lineal feet of welding were required instead of 400 feet.

• To indicate how U·S·S Stainless Steel might benefit *you* in similar constructions, we recapitulate the benefits Dravo has obtained by using Stainless:—It has enabled them to employ less expensive manufacturing procedures than those used previously. It has insured greater portability for their equipment. It has improved heat transfer and eliminated expensive refractory maintenance. Dravo is now sold on the use of Stainless Steel because, as their engineers report, it has given them a tremendous advantage over competition in many respects, one of the most important being *lower cost of manufacture.*

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
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SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

United States Steel Corporation Subsidiaries
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☐ Please send me the new book, "An Introduction to U·S·S Stainless Steel."
☐ Please have a Stainless representative call on me.

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UNITED STATES STEEL

Presenting

TWO NEW di-acro MACHINES

on display BOOTH 451

31st NATIONAL METAL EXPOSITION, CLEVELAND, OCTOBER 17-21

di-acro VARI-O-SPEED POWERSHEAR

With its range of shearing speeds from 30 R. P. M. to 200 R. P. M., the new DI-ACRO Vari-O-Speed Powershear offers a tremendous advantage in operating efficiency for high speed production shearing. The cutting cycle can be set at the maximum speed which the material can be fed for any given shearing operation as the necessity of engaging the clutch for each stroke has been entirely eliminated. With this new shearing method, fatigue is reduced, accuracy increases, production soars!

The Vari-O-Speed Powershear also produces clean cut straight edges on many delicate and unusual types of materials when sheared slowly, which in many cases could not be cut successfully with the high speed "impact" type of shearing. In all materials a clean edge free from roughness or burrs is assured because of the permanent precision of this rugged machine. Available in 12" and 24" shearing widths with capacities to 16 gauge sheet steel. Also offered in standard model with single speed. Both models equipped with non-repeating safety clutch for "single stroke" shearing.

di-acro HYDRA-POWER BENDER

Here is a revolutionary bending machine of virtually universal application, for this ONE standard machine can be quickly converted into a "custom-built" unit to exactly fit each bending job in all types of ductile materials.

The DI-ACRO Hydra-Power Bender will form simple, compound and reverse bends in tubing, angle, channel, extrusions, moldings, strip stock, bus bars, round or square rods and all other solid ductile materials.

The Vickers Hydraulic System installed in this precision bending machine provides a smooth even flow of power and places the correct bending speed for each type of material at the instant command of the operator.

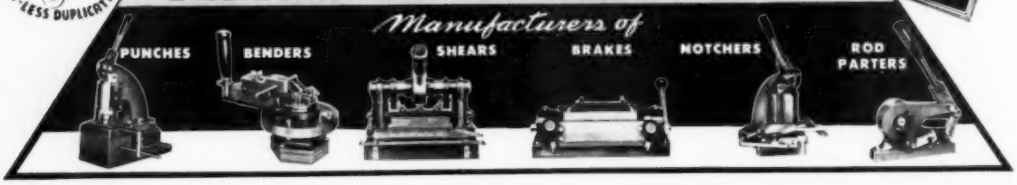
Engagement of the control lever starts the bending cycle leaving the operator's hands free until the bend is completed and the bending motion is automatically stopped. A flick of the lever returns the machine at high speed to loading position, regardless of the speed being used in the bending cycle. This is a valuable time-saving feature for production runs.

See DI-ACRO Machines in Operation at the Show or Send for Catalog ➔

DI-ACRO PRECISION MACHINES FOR DIE-LESS DUPLICATING

O'NEIL-IRWIN MFG. CO. 398 EIGHTH AVE., LAKE CITY, MINN.

Manufacturers of

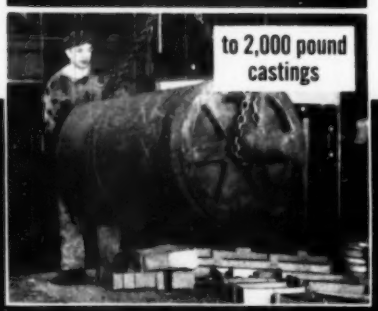


Saves $10,160 Yearly on Labor Costs!

Cuts Cleaning Time 66⅔% for Harris-Seybold

Cleveland Plant saves $40 daily on labor costs while cutting cleaning time on castings from 48 to 16 man-hours

NEW ROTOBLAST ROOM CLEANS ENTIRE FOUNDRY OUTPUT . . .



Yes—this **new** Pangborn ROTOBLAST Room completely cleans **every single casting** Harris-Seybold make for their famous offset printing presses. That means old-fashioned sand-blasting bottlenecks are eliminated . . . adding up to a **saving of 32 man-hours a day** . . . a better cleaning job in **⅓ the time! Actually $10,160 a year** are saved on labor costs alone!

Here are more savings: castings are **cleaner** than before, even though the intricate work ranges from one pound to one ton! That means **faster machining . . . less wear** on machine tools. Abrasive costs are lower with Pangborn ROTOBLAST, adding more savings to the record!

Pangborn ROTOBLAST: **Cleans faster** because it throws more abrasive over a larger area with greater density. **Cleans better** because it produces a finer surface than old-fashioned methods. **Cleans cheaper** because it requires less horsepower . . . uses less man power . . . needs less maintenance . . . eliminates need for air compressor!

FIND OUT HOW MUCH YOU CAN SAVE! No matter what you clean . . . what you cast . . . Pangborn ROTOBLAST equipment can save you money on your cleaning operation. For complete details, write today for Bulletin 211A. Address: PANGBORN CORPORATION, 1404 Pangborn Blvd., Hagerstown, Maryland.

Pangborn

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BLAST CLEANS CHEAPER with the right equipment for every job

New Combustion Safeguard

FACTORY MUTUAL
FM
APPROVED

BRISTOL ELECTRONIC PYROTROL

for gas-fired appliances

This new Bristol instrument (1) makes it impossible to light gas appliances under unsafe conditions and (2) shuts down the appliance promptly if an unsafe condition develops during operation.

A Combination of Features Found in No Other Combustion Safeguard

(1) *No special tubes needed.* You can get replacements in any radio store.

(2) *No special electrode cable needed.* For lengths up to 15 feet between electrode and Pyrotrol, use easily-obtainable BX flexible cable. Commercially available coaxial cable used for longer lengths.

(3) *You save on external wiring.* Power to operate main valve, pilot valve and ignition transformer supplied from Pyrotrol terminals.

(4) *Protects against unsafe start.* Safe-start relay prevents gas flow upon lighting off, should there be a leakage path in the electrode head or electrode cable of resistance value within normal flame operating range or a short circuit between electrode and ground.

(5) *Protects against tube failure.* Will shut down entire combustion system on loss of emission from any electron tube section.

(6) *No unnecessary shutdowns.* Prevents gas shut-off, in accordance with accepted insurance company standards, due to momentary flame flicker.

(7) *Unaffected by dust.* Completely dust-proof.

Write for Bulletin W1816. THE BRISTOL COMPANY, 106 Bristol Road, Waterbury 91, Conn. (The Bristol Co. of Canada, Ltd., Toronto, Ont.; Bristol's Instrument Co., Ltd., Lynch Lane, Weymouth, Dorset, England.)

60 YEARS...1889-1949

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Gives You the Most from Heat

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

up from the minor leagues

comes stainless sheet and strip

Stainless steel has now moved up to the major leagues. Advances in strip mill techniques have played an important part. Now, CRUCIBLE, using the best of these accepted modern techniques, plus exclusive ones of its own . . . is producing stainless by specialty steel production methods at the busy Midland Works. In the *first* mill *specifically* built for the production of stainless, top steel specialists are putting to good use $18,000,000 of new tools and buildings. When the leader in the specialty steel field applies specialty steel production methods to stainless, you can rightly expect that from CRUCIBLE you'll get the best that a half century of experience and modern tools can provide.

The new mill will produce stainless in widths of ½″ to 50″ inclusive, in all gauges, grades and finishes. This is important news to users of stainless steels, because with Trent Tube Company joining the organization, you can get stainless from Crucible in every form: sheets, strip, plates, bars, wire, forgings, castings and tubing. Crucible offers comprehensive data sheets and unsurpassed metallurgical service. Your inquiries are welcome.

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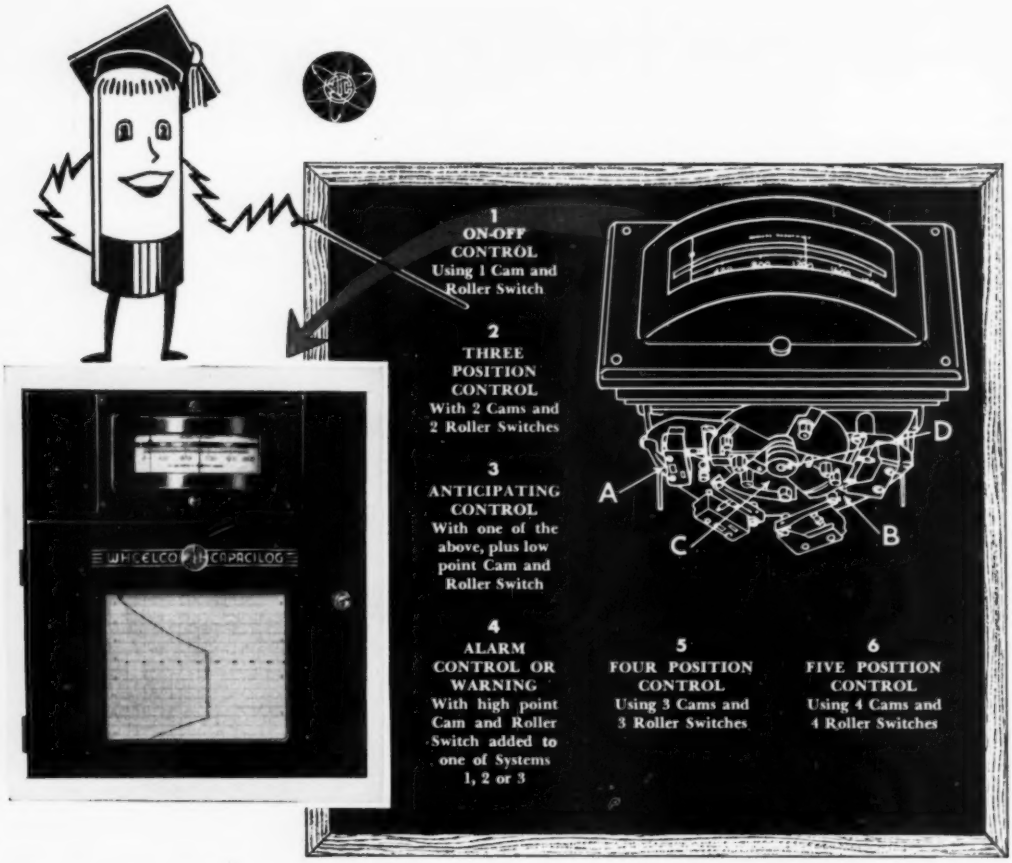
CRUCIBLE first name in special purpose steels

hot and cold rolled STAINLESS SHEET AND STRIP

STAINLESS • HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE • STEELS



Processing Industries *are sold* on the CAPACILOG *because* . . .

. . . . Engineers like the control flexibility of this Strip Chart Recorder provided by a simple micro switch arrangement. The "blackboard" illustration shows 4 roller type lever micro switches (A) located on the Control Switch Base (B) Control Cams (C) move with Vertical Shaft (D) which is linked to the Pen Assembly. With this simple mechanism, providing 6 types of control functions, a permanent record of a multitude of process variables—temperature, voltage, amperes, speed, etc.—may be obtained.

Whether your application is in the Metal, Chemical, Ceramic, Plastic or Laboratory Classification, there is a model for your purpose.

Capacilog Strip Chart Recorders use the same "Wheelco Electronic —No Contact—Principle" that is featured in 40,000 indicating pyrometer controllers which have successfully been applied in industrial processing in the past.

WHEELCO INSTRUMENTS COMPANY
835 W. HARRISON ST., CHICAGO 7, ILL.

Please send me the Bulletin(s) checked below:

- ☐ C2—Strip Chart Recorder
- ☐ Z6500—Condensed Catalog

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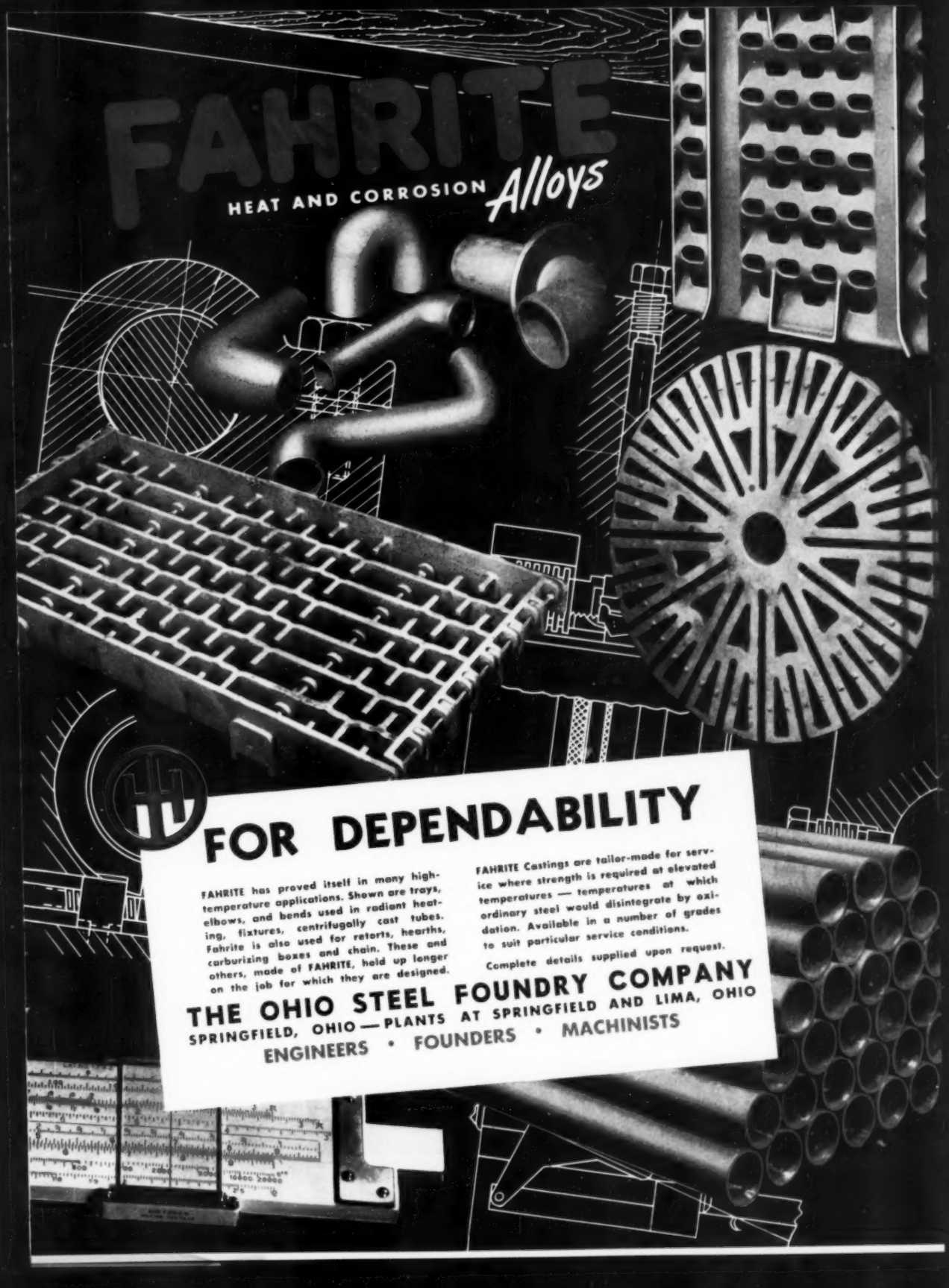
WHEELCO *Electronic* CONTROLS

RECORDERS • COMBUSTION SAFEGUARDS • CONTROLLERS



FOR DEPENDABILITY

FAHRITE has proved itself in many high-temperature applications. Shown are trays, elbows, and bends used in radiant heating, fixtures, centrifugally cast tubes. Fahrite is also used for retorts, hearths, carburizing boxes and chain. These and others, made of FAHRITE, hold up longer on the job for which they are designed.

FAHRITE Castings are tailor-made for service where strength is required at elevated temperatures — temperatures at which ordinary steel would disintegrate by oxidation. Available in a number of grades to suit particular service conditions.

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SPRINGFIELD, OHIO — PLANTS AT SPRINGFIELD AND LIMA, OHIO

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Both Are Zinc-Coated...

BUT ONE COATING LASTS 15-45% LONGER

ARMCO ZINCGRIP

REGULAR GALVANIZED

Pictured here are two small samples of zinc-coated sheet steel . . . *with equal weight* coatings.

Photo at the top is a sample of Armco ZINCGRIP; regular galvanized at the bottom. Actual field tests show the coating on ZINCGRIP has 15% to 45% *greater atmospheric corrosion resistance* than equal weight coatings on regular galvanized sheets. Exposure tests were made in seacoast and industrial areas.

TAKES SEVEREST DRAWS

The specially-applied coating on Armco ZINCGRIP has another important advantage. It takes as severe a draw as the steel base without peeling or flaking.

Think of the shop savings with a mill-coated steel you can form or draw without fracturing the zinc coating! And think of the extra sales value of this longer-life zinc coating that assures much longer service for your fabricated products.

Armco ZINCGRIP is supplied in sheets or coils. Send for a copy of the fully descriptive booklet on Armco ZINCGRIP, the special coated steel with a record of more than 12 years in proved service. Use the handy coupon. Armco Steel Corp., 3559 Curtis Street, Middletown, Ohio.

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Name _____ Title _____

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ARMCO STEEL CORPORATION

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Motors from ½ to 2 H.P. and volume up to 75 cfm. Equipped with universal motors not recommended for continuous service.
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SINGLE STAGE: For medium and light duty service, the single stage unit provides efficient and reliable service at low first cost. Pressures from 4 to 16 oz.; capacities from ½ to 20 H.P.
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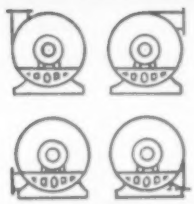
The multi-stage Turbo-compressor is recommended for all applications requiring the best. Assures long life, low maintenance and reliable service.
4 BEARING: Two types are offered for installations with coupled drive by motors with standard shafts.
Accurate alignment of these blowers is necessary for satisfactory operation, and with the Spencer design this can be easily maintained.
OUTBOARD
OVERHUNG

Spencer centrifugal type Turbo-compressors are regularly used for supplying low pressure air for oil and gas-fired furnaces, foundry cupolas, pneumatic conveyors, agitation of liquids and blowing or exhausting for many different applications. Spencer Turbo-compressors deliver air at varying volumes with a uniform pressure which eliminates the necessity of any adjustment of the blast gate at each change of load.

MECHANICAL ADVANTAGES

- Simple Construction
- Lightweight Impellers
- Wide Clearances
- Large Shafts
- Ball Bearings
- One Piece Casing

Spencer Bulletins are available as follows: Data Book No. 107, Gas Boosters No. 109, Four-Bearing No. 110, Blast Gates, No. 122, Foundry No. 112. Descriptive Bulletin 127 and Technical Bulletin 126



The discharge may be in any one of four positions on any Spencer Turbo Compressor.

359-E

SPENCER HARTFORD

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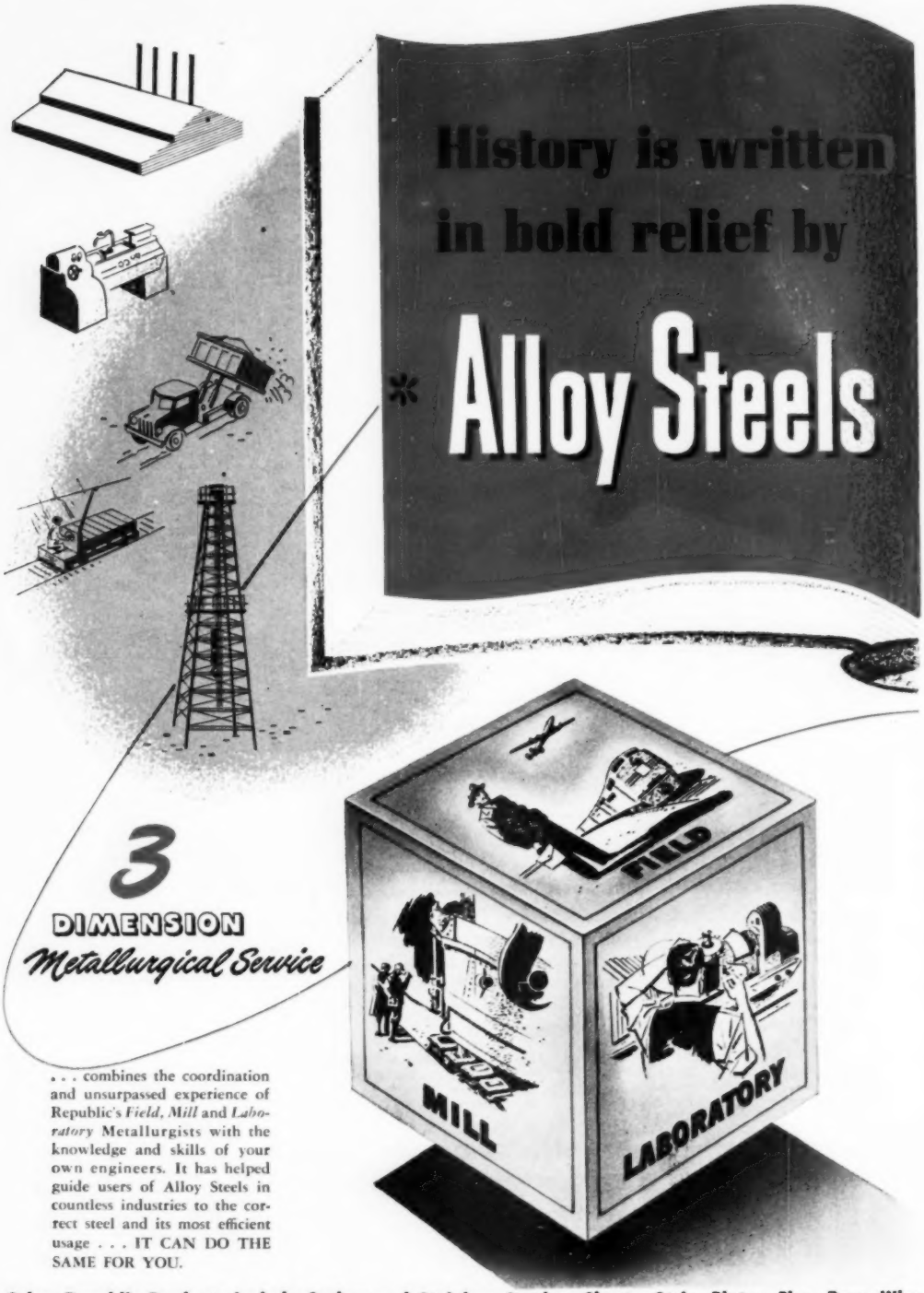
TURBO-COMPRESSORS

See Spencer at the American Gas Section, Booth 2735, at the Metal Show.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in bold relief by
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3
DIMENSION
Metallurgical Service
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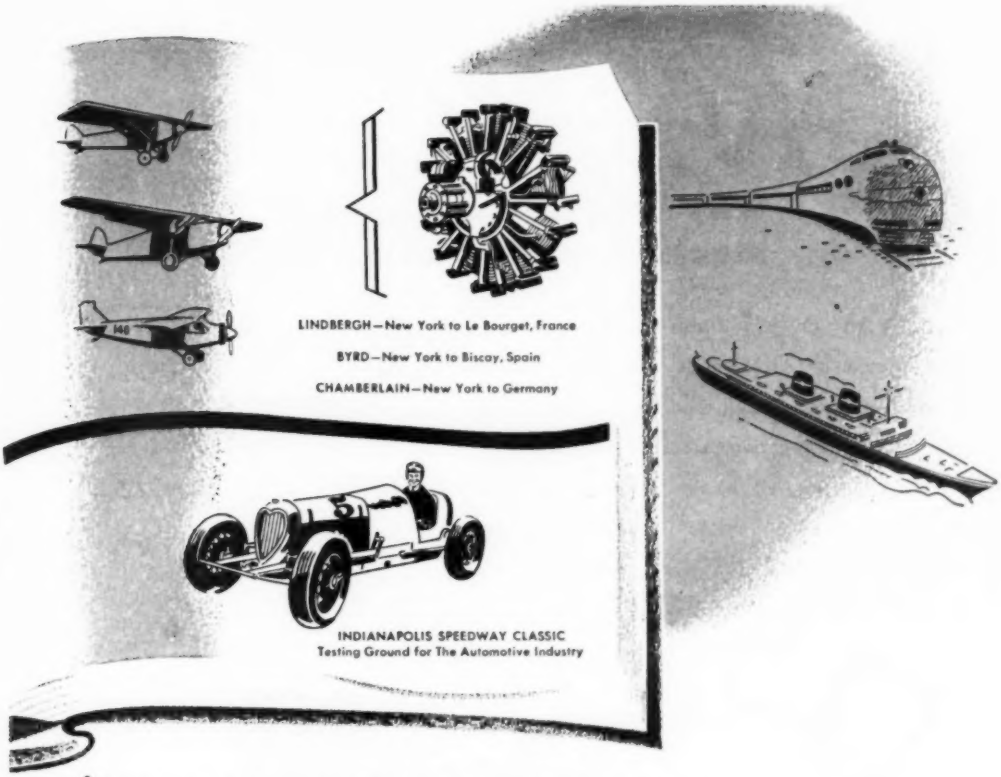
Other Republic Products include Carbon and Stainless Steels — Sheets, Strip, Plates, Pipe, Bars, Wire,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Testing Ground for The Automotive Industry

✻ *the key that unlocked the Age of Speed and Production*

Thanks to Alloy Steels, and their pioneering by Republic, the seemingly impossible often becomes a reality.

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On the pages of history stand many records of Republic Alloy Steels—in mines and mills, oil fields, railroads, throughout all industry—where they have helped and continue to make possible new speeds, new production records, new economies in operation.

Are you sure that you are using Alloy Steels to best advantage in *your* product or process? Why not check *today* with Republic—the men who *know* Alloy Steels?

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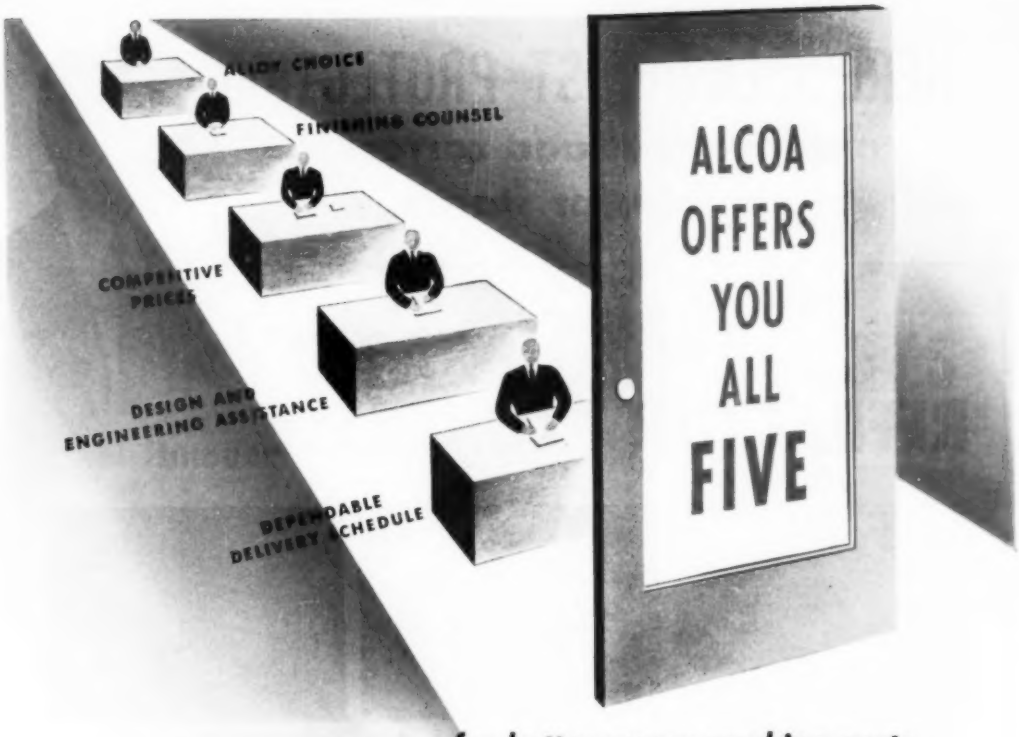

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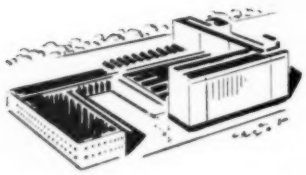

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You get all these with screw machine parts by Alcoa, plus the added advantages of aluminum parts: strength with light weight, close tolerances, added sales appeal, range of all commercial finishes plus Alumilite* finish exclusive with aluminum.

Your Alcoa representative will be glad to give you more facts about our service, and a prompt quotation. Or write ALUMINUM COMPANY OF AMERICA, 2101K Gulf Building, Pittsburgh 19, Penna.

*Patented process

ALCOA

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ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

HERE'S LOW-COST PROTECTION

against heat and corrosion in flues or stacks

LUMNITE* REFRACTORY CONCRETE

Inside of Open Hearth Flue. There are no ragged walls or flattened arches. Notice its excellent condition after 5 years of service.

The interior of this waste-gas coke oven flue was built with Lumnite concrete. No lining was needed on this job.

Shooting Lumnite Concrete lining in steel stack. This economical Lumnite lining in stacks protects against corrosion and heat.

Flues are fully protected against heat and corrosion when Lumnite Refractory Concrete is used. Whether used as a monolithic structure or as a lining in flues, Lumnite resists high temperatures and the attacks of condensate and sulphurous gases; withstands the abrasive action of high-velocity gases and fly ash. In stacks, smooth, jointless Lumnite linings allow no breathing, boost drafts and keep gas temperatures up.

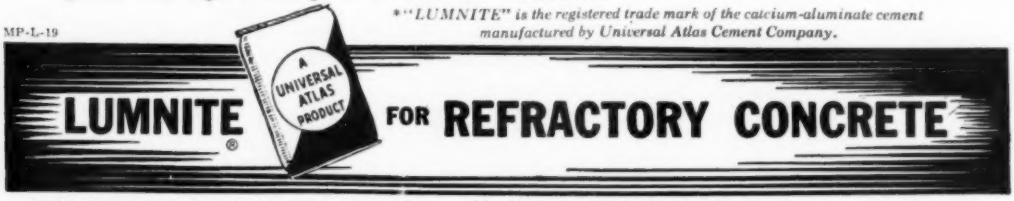
Lumnite Refractory Concrete is easily installed. It may be placed quickly in any size, shape or thickness. Stack linings of Lumnite and corrosion-resistant aggregate are trowelled in place or "shot" by concrete gun over reinforcing mesh. Maintenance costs are low. Outage time for repairs is kept to a minimum because Lumnite reaches service strength in 24 hours or less. Thus long service and easy maintenance give you many a *plus* in economical operation. For further information on Lumnite Refractory Concrete in flues and stacks, write to Lumnite Division, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), Chrysler Building, New York 17, N. Y.

SPECIFY CASTABLES MADE WITH LUMNITE

Where suitable aggregates are not readily obtainable, tailor-made mixtures, ready for immediate use, are available. These factory-prepared mixtures of Lumnite and selected aggregates, when mixed with water on the job, may be cast into place for furnace door linings, arches, blast furnace pads, annealing furnace car tops and door linings. Special shapes can be cast in molds—ready within 24 hours. Castables made to meet specific temperature and insulation requirements are prepared by manufacturers of refractories and sold by their distributors.

*"LUMNITE" *is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.*

MP-L-19



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ROLOCK

FABRICATED ALLOYS

Inconel Homocarb Furnace Retorts with *One Piece* Fabricated Sand Seal Rings

Rolock's construction of sand seals adds the exclusive and crowning feature that makes this Inconel Homocarb furnace retort a leader in its field. All radial welds are eliminated . . . Inconel seal is integral with retort.

The One Piece seal, truly round, insures perfect fit; wrought material with sound, full penetration, gas tight welds . . . the weld metal having the same strength and resistance to high heat and corrosion as the parent metal itself . . . prevents atmosphere leakage, lengthens life of electric heating elements, reduces maintenance.

If you've been troubled by embrittlement from carburizing or gas cyaniding atmospheres, and you want to cut heating costs, improve work, specify Rolock Inconel Retorts with the tried and proven One Piece integral Sand Seal.

Fabricated Inconel Retort . . . available for 15", 20" and 25" Homocarb furnaces.

It's one piece . . . It's Inconel . . . It's Integral with the retort . . . It's exclusively a ROLOCK design for original or replacement equipment.

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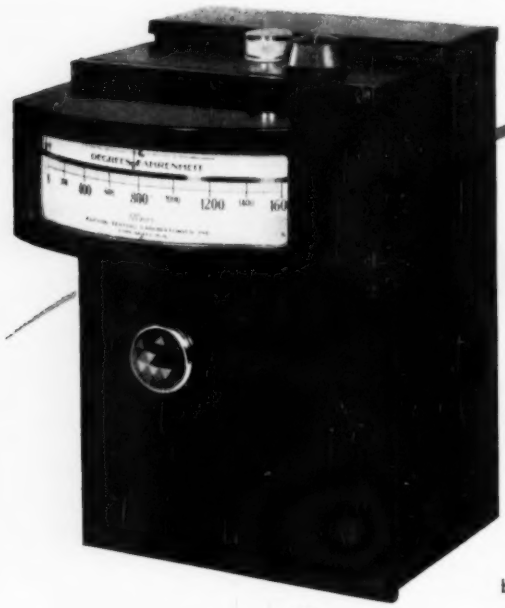

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Alnor Accuracy

Now—at a cost far less than you think—you can bring fool-proof electronic heat control to furnace, melting pot, oven, kiln—in fact, to any heating device using electricity, gas or oil! The Alnor Electronic Pyrometer Controller is a fine, precise instrument, at home in laboratory or production operations. Yet, its simplified design means real savings to you! Pyrometer movement is double-pivoted on jeweled bearings; 6-inch mirrored scale is easy to read; automatic cold-end compensator, weather-proof, dust-tight case—a truly high-quality instrument you can afford!

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Other
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Die Steels
for Hot Work

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CHOICE
MARVEL
FORGE-DIE
RED CUT SUPERIOR

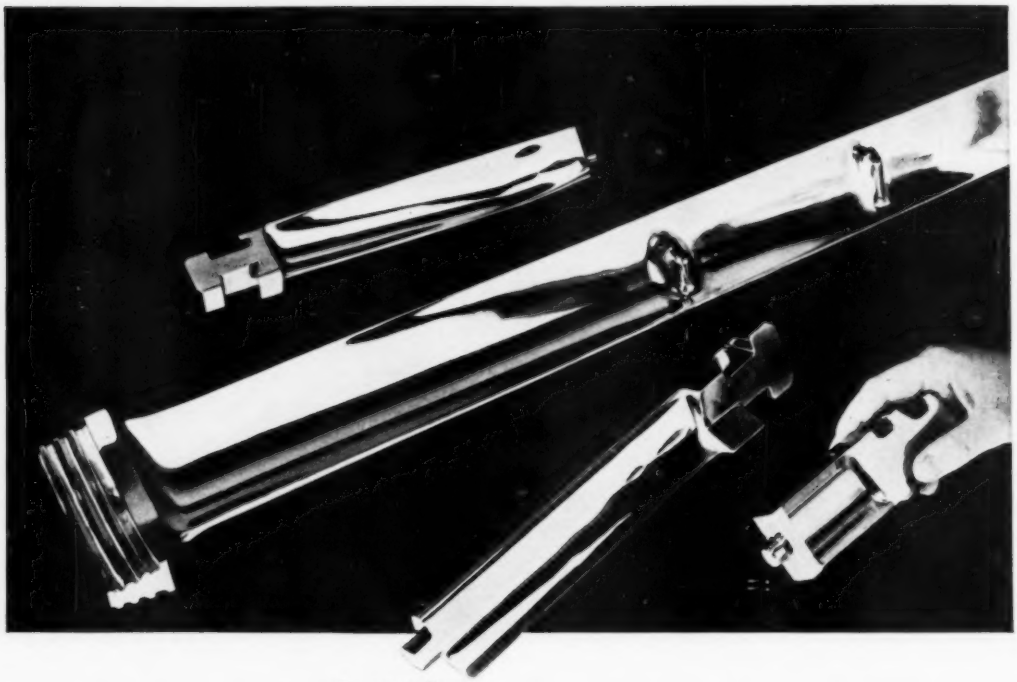
Famous for resisting high temperatures without checking or cracking . . . widely used in hot press forming of steel and brass

This low carbon, high tungsten steel *stands up* under dull red heat in severe die applications. It is fine for dies and dummy blocks in rod and tube extrusion . . . excellent in upsetter machine service . . . and tops for dies for hot forming brass and steel on presses. HOTPRESS is a good steel to know and use. Let us arrange an introduction!

FIRST QUALITY TOOL STEELS

Vanadium-Alloys
STEEL COMPANY
LATROBE, PENNA.

Colonial Steel Division — Anchor Drawn Steel Co.



Where *workability* takes equal importance with Strength, Toughness, Corrosion-Resistance

High strength, toughness and corrosion-resistance make stainless steel the ideal material for steam turbine blades—but there's another quality needed, too—WORKABILITY. And you'll find it well developed in Republic ENDURO.

ENDURO responds uniformly in forging—as demonstrated by the largest blade above which was forged from a 7½" x 3" bar. All four blades indicate that a substantial amount of machining was necessary—and here again ENDURO shines, particularly in the free-machining grades.

In addition, ENDURO Cold Finished Bars—processed by Republic's Union Drawn Steel Division—provide close tolerances, accuracy of section, uniform soundness and fine surface finish that combine to hold unit costs and rejection losses to lowest possible levels.

Write us for further information on Republic ENDURO Stainless Steel Bars—both hot rolled and cold finished—also ENDURO wire.

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STAINLESS STEEL

REPUBLIC STEEL

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SEYMOUR NICKEL SILVER

Wherever Plating Must Undergo Friction

The piston stems in trumpet valves are typical of the use of Seymour Nickel Silver for maintaining a matching color. Constant friction, hundreds of polishings, finally wear off the plating of these stems, yet they still match the surrounding plate.

Seymour Nickel Silver is also used for tube braces, mouthpieces, and numerous other plated trumpet parts where wear must not show. In addition to its clear-through, silvery white color, the extreme rigidity, high corrosion resistance and good workability of Seymour Nickel Silver make it a preferred choice for many another similar application.

THE SEYMOUR MANUFACTURING COMPANY, SEYMOUR, CONNECTICUT

Other screw machine products of Seymour Nickel Silver Rod

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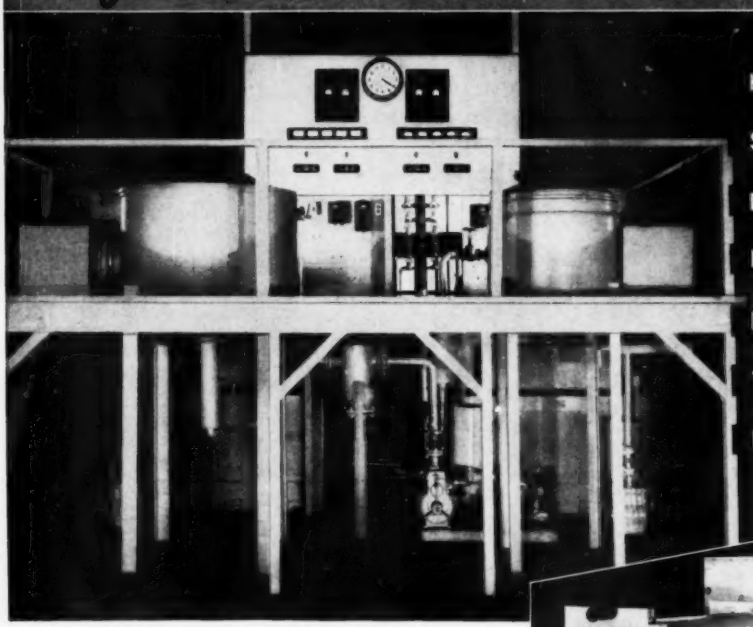

HEAT TREATING
SINTERING
DEGASSING
BRIGHT SOLDERING
METAL DISTILLATION
THERMAL REDUCTION
MELTING and CASTING

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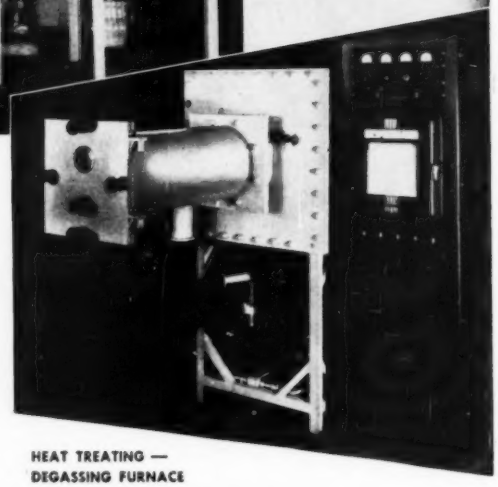
High Vacuum Metallurgy is not new as laboratory technique. It *is* new as a practical industrial operation.

For the first time, National Research Corporation offers its services to design and build, to your requirements, furnaces which operate in the micron pressure range. Pressures run as low at 10^{-4} mm. Hg. absolute.

Six years' experience in the engineering and construction of High Vacuum metallurgical equipment is at your disposal. Write National Research Corporation.



HEAT TREATING — DEGASSING FURNACE

For ILLUSTRATED BROCHURE, *write to:*
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National Research Corporation,
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RF HEATING

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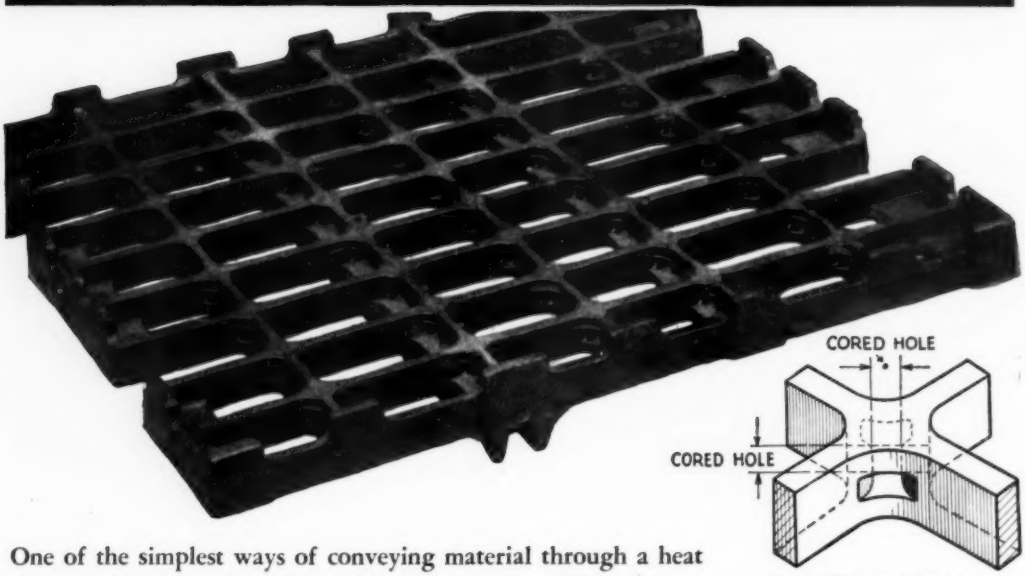
MORE LOAD · LESS DISTORTION · LONGER LIFE



THE MISCO PRINCIPLE OF GRID-BAR DESIGN

Grid intersections are cored horizontally and diagonally through the neutral axis. Metal thus removed from regions of low stress is added to areas of high stress, where it increases load capacity, reduces distortion, and gives much longer life. U. S. Pat. 2242554.

One of the simplest ways of conveying material through a heat treating furnace is by means of the pusher tray. The simplest kind of pusher tray is the one-piece grid type illustrated above. The basic design is light, efficient and strong. Add the Misco principle of grid-bar design and here is the strongest, most rugged tray construction yet devised. Users are enthusiastic, reporting tray life up to 3½ years. Let us build maximum endurance into YOUR equipment.

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- **Push-button control. The new Ajax-Northrup converter is self-tuning, does not require any adjustments while melting**
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AJAX ELECTROTHERMIC CORPORATION

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A
Abroff Mfg. Corp.
Acker & Man, Inc.
Adams Construction Co.
Addressograph-Multigraph
Advertising Metal Display
All-Steel Equip. Co.
Allbright-Nell Co.
Allen Bradley Co.
Allen Mfg. Co.
Allis-Chalmers Mfg. Co.
Altorfer Bros. Co.
Aluminum Co. of America
American Air-Filter Co. Inc.
American Airlines Inc.
American Ball Bearing Corp.
American Brake Shoe Co.
American Brush Corp.
American Can Co.
American Cast Iron Pipe Co.
American Chain & Cable Co. Inc.
American Electric Fusion Corp.
American Hardware
Corbin Cabinet Lock Div.
American Hollow Boring Co.
American Instrument Co., Inc.
American Meter Co., Inc.
American Optical Co.
American Phenolic Corp.
Anderson-Carlson Mfg. Co
Anderson Co.
O. L. Anderson Co., Inc.
Apex Smelting Co.
Armstrong Cork Co.
Art-Craft Optical Co., Inc.
Atchison, Topeka & Santa Fe Ry. Co.
Auto Spec. Mfg. Co.
Automatic Electric Co.
Automatic Gas Co. of Columbus, Inc.

B
Badger Tool & Eng. Co.
B. A. Ballon & Co., Inc.
The Bassick Co.
C. J. Bates & Sons
Bauer & Black Div., Kendall Co.
Bayuk Cigars, Inc.
Beatrice Steel Tank Mfg. Co.
Bell & Gossett Co.
Bell & Howell Co.
Belle City Mfg. Co. Inc.
Bendix Aviation Corp.
L. A. Benson Co. Inc.
Bernardin Bottle Cap Co. Inc.
Blizzard Mfg. Co.
Blue Ridge Pressure Castings
Bolens Products Co.
Bonney Forge Tool Works
Boston Wire Stitcher Co.
James H. Boye Mfg. Co.
Brasco Mfg. Co.
Chas. D. Briddell, Inc.
Bristol Co.
Broderick Co.
D. S. Brown Co.
Bucyrus-Erie Co.
Edw. G. Budd Co.
Buick Oldsmobile Pontiac Assembly Div., General Motors Corp.
Burgess-Norton Mfg. Co.
Burndy Eng. Co. Inc.

C
Caine Steel Co.
Cameron Mfg. Corp.
Carbo Tool & Die Co.
Carnegie-Illinois Steel Corp.
Certain-Teed Prod. Corp.
W. M. Chace Co.
Chain Belt Co.
Chamberlain Corp.
Cherry-Burrell Corp.
Chicago Auto Spring Co.
Chicago & North Western Ry. Co.
Chicago Pneumatic Tool Co.
Chicago Rawhide Mfg. Co.
Chicago, Rock Island & Pacific RR Co.
Chicago Screw Co.
Chicago, South Shore & South Bend RR
Chopie Tool & Die Co.
Chrysler Corp.
W. M. Cissell Mfg. Co.
Clayson-Forenz Co.
Clifton Conduit Co.
Colgate Mfg. Corp.
Collyer Insulated Wire Co., Inc.
Corn Products Refining Co.
Cummins Business Machines
Cutler-Hammer, Inc.

D
Davis & Furber Mach. Co.
Day Brite Lighting, Inc.
Deere & Co.
Detroit Gear Div., Borg-Warner Corp.
Detroit Stamping Co.
Diamond Expansion Bolt Co., Inc.
Doehler-Jarvis Corp.
Dole Valve Co.
E. I. DuPont de Nemours & Co., Inc.
Dynamatic Corp.

E
Eagle Pencil Co. Inc.
Eastman Machine Co.
Eclipse Sleep Products, Inc.
Ehlert Tool Eng. Co.
Electric Storage Battery Co.
Emerson Electric Mfg. Co.
Essex Wire Corp.
Chicago Transformer Div.
R-B-M Div.
Eveready Tool Co.
Eversharp, Inc.

F
Fafnir Bearing Co.
Ferrara Spring & Parts Co., Inc.
Fischer & Porter Co.
Michael Flynn Mfg. Co.
Foreman Mfg. Co.
Frazer & Jones Co.

G
General Cable Corp.
General Electric Co.
General Motors Corp.
Electro-Motive Div.,
Frigidaire Div.
General Tool & Die Corp.
Gerotor May Corp.
Gibson Refrigerator Co.
Girard Mfg. Co.
Gisholt Machine Co.
Great Lakes Spring Corp.
Green Bay Drop Forge Co.

H
Hammond Brass Works
Harrington & King Perforating Co.
Hartford Machine Screw Co.
J. F. Helmhold & Bro.
Hi Level Screw Prod. Co.
High Speed Hammer Co. Inc.
Hotpoint, Inc.
Houdaille-Hershey Corp.
General Spring Bumper Div.
Huntington Div.
Oakes North Chicago Div.
M. D. Hubbard Spring Co.
B. H. Hubbert & Son, Inc.
Hummer Mfg. Co.
Hy-Pro Tool Co., Inc.
Hydraulic Press Mfg. Co.

I
Illinois Tool Works
International Projector Corp.
J
International Tool & Gauge Co.
James Mfg. Co.
Johnston Lawn Mower Corp.
Jones & Laughlin Steel Corp.
A. O. Joslin Mfg. Co.

K
Kent Galvanizing Co.
Kewanee Mach. & Conveyor Co.
Klein Mfg. Co.
Kraeuter & Co., Inc.
Krapp Forge Co.

L
L-S Mfg. Co.
A. Lakin & Sons
Landis Machine Co.
Leach Co.
Ledkote Products Co.
Leman Machine Co.
Line Material Co.
Link Belt Co.
Lloyd Mfg. Co.
Lobdell-Emery Mfg. Co.
Locke Insulator Corp.
Louden Machinery Co.
Lux Clock Mfg. Co.

M
Macey Co., Div. Earle S. Irwin Co.
Magnetics, Inc.
Malleable Industries
Manganese Steel Forge Co. Inc.
Manufacturers Machine & Tool Co.
Marathon Elec. Mfg. Co.
McGraw Electric Co.
McHenry Mfg. Co.
Mid-States Steel & Wire Co.
Midwest Brass Forging Co.
Milford Metal Treating Co.
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Minneapolis-Honeywell Regulator Co.
Modine Mfg. Co.
Mojonnier Bros. Co.
Monarch Marking System Co.
Mossberg Pressed Steel Corp.
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N
Nachman Corp.
Nash-Kelvinator Corp.
National Elec. Welding Machine Co.
National Enameling & Stamping
National Pressure Cooker Co.
National Rivet & Mfg. Co.
New Jersey Instrument Corp.
New Monarch Machine & Stamping Co.
Newark Stove Co.
Northern Electric Co.
Northern Pacific Railway Co.
Northwest Metal Prod. Inc.

O
Ohio Brass Co.
Oliver Corp.
P
Pacific States C. I. Pipe Co.
Paramount Wedding Ring Co.
Pearlduck, Inc.
Peerless Roll Leaf Co. Inc.
Penn Rivet & Machine Co.
Petersen Mfg. Co.
Phelps Dodge Corp.
Philco Corp.
Pick Mfg. Co.
H. K. Porter Co.
American-Fort Pitt Spring Div.
Precision Mfg. Co.
Progressive Mfg. Co.

R
Radio Corp. of America
R. J. Randel Tool Co.
Manhattan Rubber Mfg. Div. of Raybestos-Manhattan, Inc.
F. B. Redington Co.
W. H. Reisner Mfg. Co. Inc.
Reliable Electric Co.
Remington Rand, Inc.
Republic Steel Corp.
Rewelac Mfg. Co.
Rheem Mfg. Co.
Richardson Scale Co.
Richmond, Fredericksburg & Potomac RR Co.
Roy E. Roth Co.
Wm. & Harvey Rowland, Inc.
Royal Typewriter Co.
Ruud Mfg. Co.
Jos. T. Ryerson, Inc.

S
Safety Socket Screw Co.
Sager Lock Works
Schultz Die Casting Co.
Scovill Mfg. Co.
Seneca Wire & Mfg. Co.
Servel, Inc.
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Staatsburg Ice Tool Works
Standard Dredging Corp.
Standard Shade Roller Corp.
Standard Steel Spring Co.
Steel Fabricating & Engineering Co.
Stewart Die Casting Div.
Stockham Pipe Fittings Co.
Sylvania Industrial Corp.

T
Tait Mfg. Co.
Tennessee Coal, Iron & R. R. Co.
Texas Co.
Thomas & Skinner Steel Products Co.
Tillotson Mfg. Co.
Timken Roller Bearing Co.
Tobin Tool & Die Co.
Townsend Co.
Triangle Auto Spring Corp.
Triplett Electrical Instrument Co.
Tube Turns, Inc.

U
U. S. Cloth Cutting Mach. Co.
V
U. S. Metals Products
United-Carr Fastener Corp.
Universal Chain Co. Inc.
Universal Oil-Seal Co.
Ushco Mfg. Co., Inc.
Vince Forging & Mfg. Co.
Vollrath Non-Ferrous Metal Foundry

W
Waterloo, Cedar Falls & Northern RR
Watson Elevator Co. Inc.
Waukesha Motor Co.
Weaver Mfg. Co.
Webster Electric Co.
Western Electric Co., Inc.
Wetmore Reamer Co.
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John Wood Mfg. Co., Inc.
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Y
Yale & Towne Mfg. Co.
Z
Ypsilanti Reed Furniture Co.
Zenith Radio Corp.

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A DIVISION OF Sunbeam CORPORATION
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A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM STEWART furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM STEWART engineer will be glad to call and discuss your heat treating problems with you.

Mail this coupon for complete information on furnaces to meet your needs:

- ☐ Atmosphere-controlled
- ☐ Banderizing
- ☐ Brazing furnace
- ☐ Car bottom
- ☐ Case hardening
- ☐ Combination
- ☐ Complete toolroom
- ☐ Continuous production heat treat line
- ☐ Electric high speed
- ☐ Electric pre-heat
- ☐ Forging
- ☐ Galvanizing
- ☐ Gas carburizing
- ☐ Gas nitriding
- ☐ High speed steel
- ☐ Metal melting
- ☐ Oven
- ☐ Pot
- ☐ Recirculating
- ☐ Rivet heaters
- ☐ Rotary hearth forge
- ☐ Soldering iron heaters
- ☐ Tempering
- ☐ Tool hardening

Name _____ Title _____
Company _____
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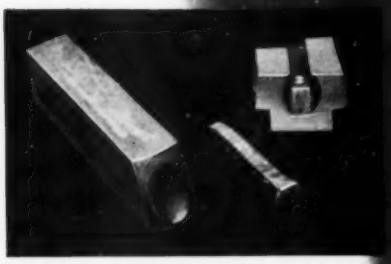
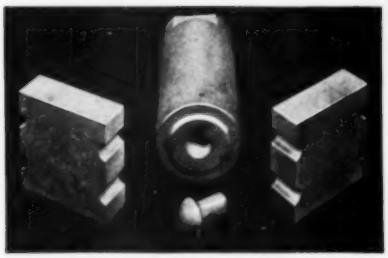


Tool costs took a nosedive when Hot-Work 8 was used for the hot-forging of steel spikes up to 5/8-in. square. Spike production now averages 200,000 for dies; 3,100,000 for grippers; and 1,100,000 for pointers. Even longer life is obtained in the production of smaller spikes.



Longer tool life resulted when Hot-Work 8 was used for these header and gripper dies in the semi-automatic manufacture of steel rivets. These dies outproduce other hot-work steels previously used. One set of dies turns out 45,000 rivets of 5/8-in. to 3/4-in. size in 8 hours.

Quick Facts about HOT-WORK 8

	C	Cr	Mo	V
TYPICAL ANALYSIS:	0.60	3.60	8.50	1.75

RED-HARDNESS: High. Excellent resistance to heat-checking and surface wash. Withstands repeated drastic cooling.

WEAR-RESISTANCE: High. For maximum service life in the medium- and high-temperature ranges. Hot-Work 8 gives excellent service life in applications where the tool or die reaches temperatures as high as 1400 F. The material being worked has, of course, much higher temperatures.

SHOCK-RESISTANCE: Good. Stands up under heavy impacts.

HEAT-TREATMENT: Anneal at 1600 F, furnace-cool. Pre-heat to 1600 F prior to hardening. Harden at 2150 to 2200 F, followed by air-quench. Temper at 1120 F for best wear-resistance; at 1200 F for best shock-resistance. Rockwell C-44 to 55.

Write us for your copy of the new booklet, "Bethlehem Hot-Work Tool Steels."

Bethlehem HOT-WORK 8

improves high-temperature TOOL LIFE

Hot-Work 8 is a veteran hot-work tool steel that cuts tool costs because of its high wear-resistance in the higher range of operating temperatures. High resistance to surface wash and heat-checking also account for its long service life on severe hot-work applications. It all adds up to longer life, fewer redressings . . . and lower costs.

Choose Hot-Work 8 when temperatures are high or variable; and when the tool or die is subject to drastic cooling during operation. Hot-Work 8 is versatile because of its excellent balance of properties for such applications as crowners, dollies, hot punches, stamps, striking dies, hot headers, hot shear blades, hot stamps, trimmers, and gripper dies. Full details are available from the nearest Bethlehem sales office or tool-steel distributor.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

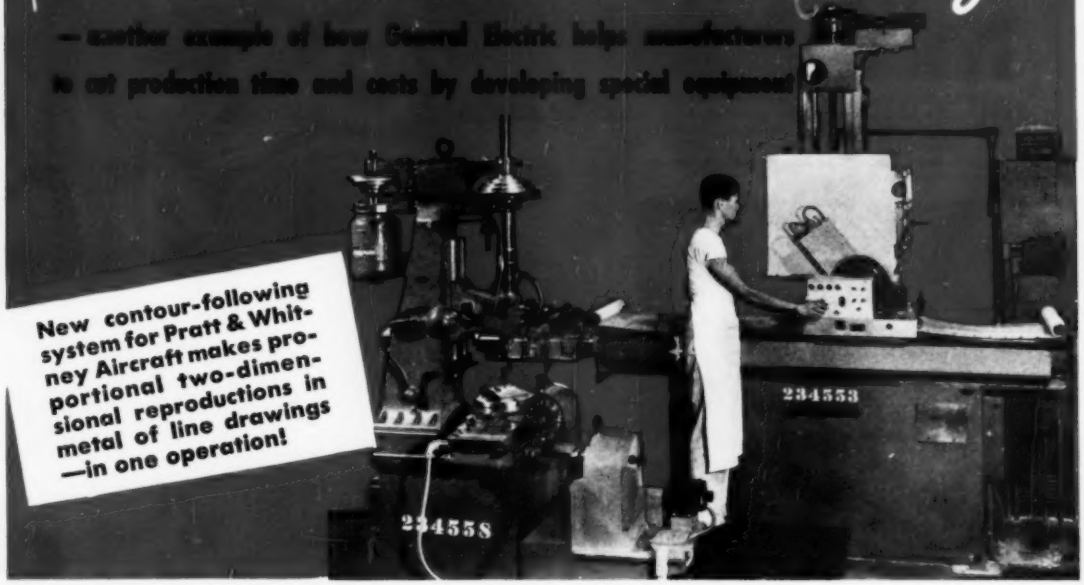
Export Distributor:
Bethlehem Steel Export Corporation

BETHLEHEM STEEL

HOT-WORK 8...one of Bethlehem's Fine Tool Steels

NEEDED . . equipment for "Metaltelepathy"

— another example of how General Electric helps manufacturers to cut production time and costs by developing special equipment

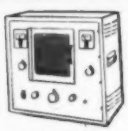

New contour-following system for Pratt & Whitney Aircraft makes proportional two-dimensional reproductions in metal of line drawings —in one operation!
234553
234558

When seeking a way to make two-dimensional reproductions in metal of line drawings, which would speed up the production of air-foil metal master patterns, engineers at Pratt & Whitney Aircraft called in General Electric. Working closely with Pratt & Whitney Aircraft engineers, G-E designers developed a new type of contour-following system. Cost of this equipment is justified for this special application because the system cuts the cost of producing a new metal master pattern by about 75 per cent and reduces production time by about 80 per cent. Although not applicable to conventional production, the equipment gives Pratt & Whitney Aircraft a valuable new tool.

A G-E Instrument for Your Problem

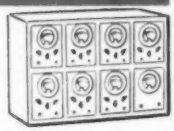
You may find that G-E engineers can help you by recommending one of the many stock G-E devices and instruments. Your problem, especially if it is one common to industry, may even justify developing new equipment. Write today for help to *Apparatus Department, General Electric Company, Schenectady, N. Y.*

Better Testing Means Better Products



Coil Testing

Time, Speed and Torque



Force, Strain and Thickness Gages

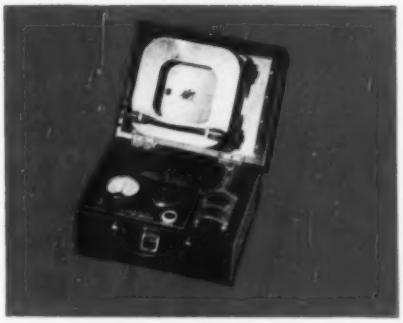
THERE ARE G-E TESTING AND MEASURING EQUIPMENTS FOR NEARLY EVERY INDUSTRIAL PROCESS

To Cut Costs of Manufacturing or Servicing Rotating Machines

—use the G-E portable dynamic balancer

By using the G-E portable dynamic balancer to balance rotors in their own bearings, you can drastically reduce the time and cost of balancing rotors in generators, motors, and in other rotating machines. The balancer is easy to use and saves time. One operator alone can balance two-bearing machines, and he needs to make only three runs.

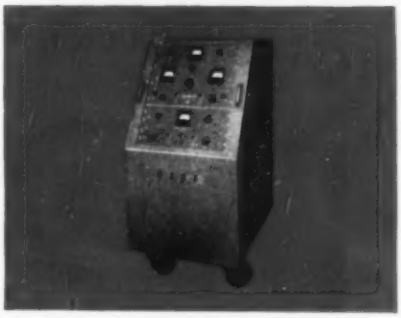
Ideal for factory-testing rotating machines, the balancer is portable. You can use it for installation or maintenance work, and for field service on any rotor within a speed range of 600 to 6000 rpm and weighing more than 30 pounds. Write for GEA-320.



To Locate Leaks in Closed Systems

—use the G-E Type M Leak Detector

By locating even the smallest leaks while your products are on the production line, you reduce operating costs, cut service expense in the field—and safeguard the good will of your customers. Used in G-E refrigerator production for more than two years, the Type M detector uses helium as the tracer. The detector is so sensitive that it can detect one part of helium in 200,000 parts of air. Write for GEC-336.

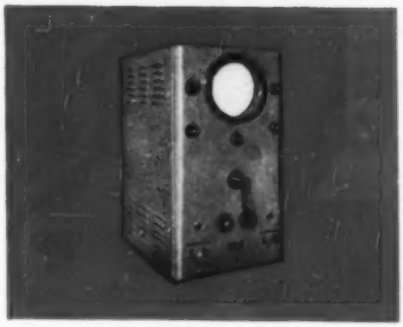


To Detect Insulation and Winding Faults Quickly

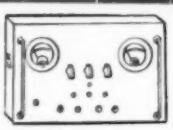
—use the G-E winding-insulation tester

You can speed up production-line testing of motors, transformers, and generators by using the G-E winding-insulation tester. At one G-E plant, for example, more than 4000 motors a week are tested with one device.

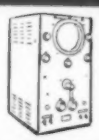
Less than one minute is required for a complete test, which includes resistance, impedance, turn-balance, and complete high-potential tests. The operator can determine the nature of defects by the wave shapes of the oscillograms on the screen of the tester. Write for GEC-321.



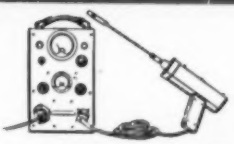
Materials Testing



Chemical Analysis



Insulation Tester



Leak Detector

Vibration and Sound

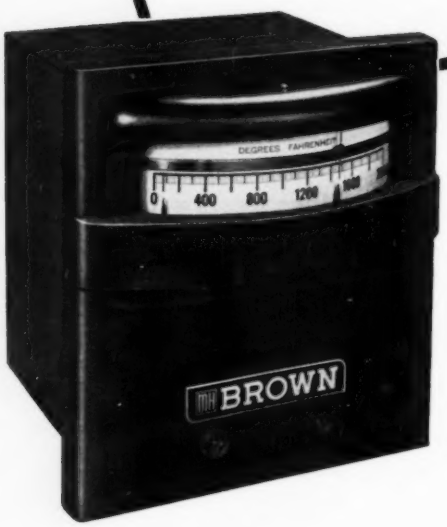
GENERAL ELECTRIC

You've heard about it...here it is!

The NEW

PYR-O-VANE

modern millivoltmeter controller



THE NEWS is out about this latest addition to the Brown line of temperature controllers . . . hundreds of metallurgists have been told the full story . . . and reports of high praise are coming in from the field! No wonder the reception is so enthusiastic . . . here are the more important reasons!

- √ Corrective action is instantaneous . . . provides *continuous non-cyclic control.*
- √ Separately enclosed high-resistance galvanometer, more sensitive and powerful, reduces maintenance.
- √ Electronic control unit plugs in and is highly immune to ambient temperature and humidity changes.
- √ "Fail-safe" design and thermocouple burn-out feature protect work load.
- √ Case is universal . . . for flush or surface mounting.

Your local Honeywell engineer is ready to give you the facts and figures. Call him in today . . . or write for a copy of Specification Sheet 112.

BROWN INSTRUMENTS — WORLD'S LARGEST ORGANIZATION FOR ADVANCED INSTRUMENTATION AND CONTROL — WELLFIELD VALVES

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
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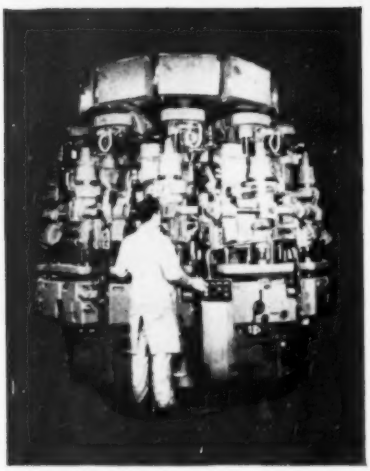
Branch offices in 73 principal cities of the United States, Canada and throughout the world

MINNEAPOLIS Honeywell — *Advanced Instrumentation* FOR METAL PROCESSING — BROWN INSTRUMENTS



"One costly shutdown after another dogged our machine shop operations until we finally learned the reason. Our circulating oils were foaming and oxidizing which caused sludge formation and critical corrosion damage to our equipment.

"A Cities Service Lubrication Engineer suggested a change in the circulating oils. We tried a Cities Service Pacemaker 'T' oil. These multi-purpose oils are fortified against foaming, oxidation and rust.

"Results were immediate. Costly shut-downs were reduced by over 200%. Efficiency of the whole line improved and quality of production was substantially stepped up."

Free—If you use cutting oils, write for our booklet "Metal Cutting Fluids." Write Cities Service Oil Company, Room 493, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE PACEMAKER "T" MULTI-PURPOSE OILS

★ For Hydraulic systems ★ For Air Compressors ★ Other circulating systems

CITIES SERVICE

"much better control and a Better Product"

with HEVI DUTY box type FURNACES....

• Typical of many unusual applications is the process of annealing and evacuating vacuum jacketed glassware in this Hevi Duty box type furnace at the Sinclair Refining Company's Research and Development Department at Harvey, Illinois.

The pumps under the furnace evacuate the glassware. Temperature is set at 1022° F. for annealing and at 700° F. for degassing. Engineers say, "Much better control and a better product are possible with a furnace of this type."

Write for bulletin HD-441. It describes construction details and gives complete specifications of twenty sizes and types.

Hevi Duty Electric furnaces have long been standard in research laboratories. There are many types and sizes for your specialized needs. Tell us your problems . . . our engineers will supply the answers.

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY

DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

MILWAUKEE 1, WISCONSIN

PARK "200" QUENCHING OIL

-hardens important landing gear parts made for world's largest bomber

THREE LANDING GEARS on the Consolidated Vultee B36 help support 326,000 pounds, maximum gross weight of this giant of the skies, the world's largest bomber.

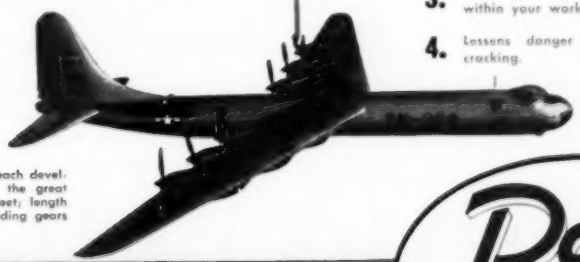
Rigid government heat treat specifications, applicable to landing gear parts, include oil quenching. Park "200" quenching oil was chosen for its ability to develop maximum physical properties of steel without danger of distortion or breakage.

Highly efficient Park "200" cools steel faster in the upper temperature ranges. Its final cooling stage is slow and uniform, rendering best surface hardness and depth of hardness penetration without danger of warping or cracking. May be used as a quench from any heat treating medium without becoming rancid, breaking down, or losing quenching efficiency.

Call your Park representative or write today for complete details. 36 page illustrated catalog-manual, loaded with helpful heat treating information, available on request.

PARK "200" QUENCHING OIL

1. Cools work rapidly in high temperature ranges.
2. Removes heat slowly, uniformly in low temperature ranges.
3. Minimizes temperature differentials within your work.
4. Lessens danger of warping and cracking.



Six 28-cylinder engines, each developing 3500 h.p., power the great B-36. Wingspan is 230 feet; length 162 feet. Huge main landing gears carry four wheels each.

• Liquid and Solid Carburizers • Cyanide, Neutral, and High Speed Steel Salts • Coke • Lead Pot Carbon • Charcoal • No Carb • Carbon Preventer • Quenching and Tempering Oils • Drawing Salts • Metal Cleaners • Kold-Grip Polishing Wheel Cement

Park

CHEMICAL COMPANY

8074 Military Ave., Detroit 4, Mich.

FAHRALLOY CASTINGS "laugh" at HEAT and CORROSION

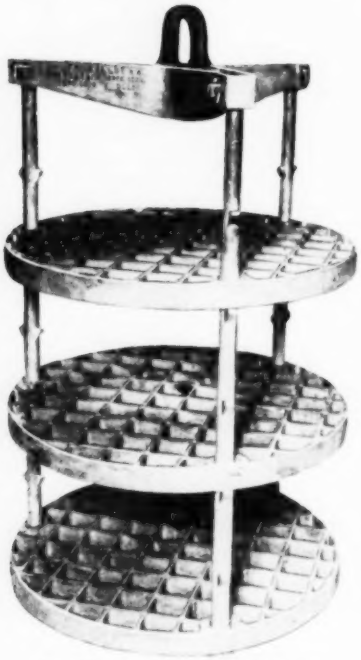
Fahralloy chromium-nickel alloys ably withstand the ravages of high temperatures and corrosion. There are three important reasons:

(1) *Every casting is made from "Virgin metal".*

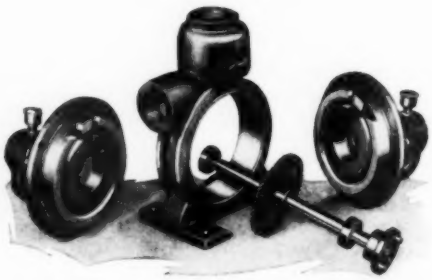
(2) Laboratory control of components in every melt.

(3) A grade of Fahralloy to master every condition of heat and corrosion or conditions involving both.

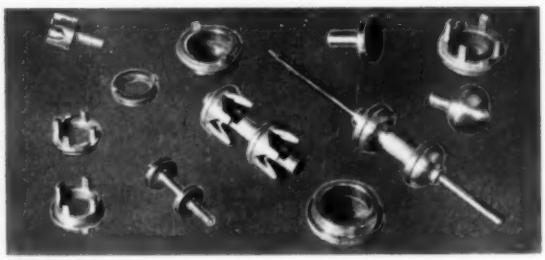
Typical Fahralloy castings are shown—long-time users praise their uniformity and long service life, resulting in maximum over-all economy.



Fahralloy fixture for handling parts in heat-treating.



Fahralloy parts for pump handling hot, corrosive liquids.



Machined Fahralloy valve castings for an application involving abrasive wear and corrosion.

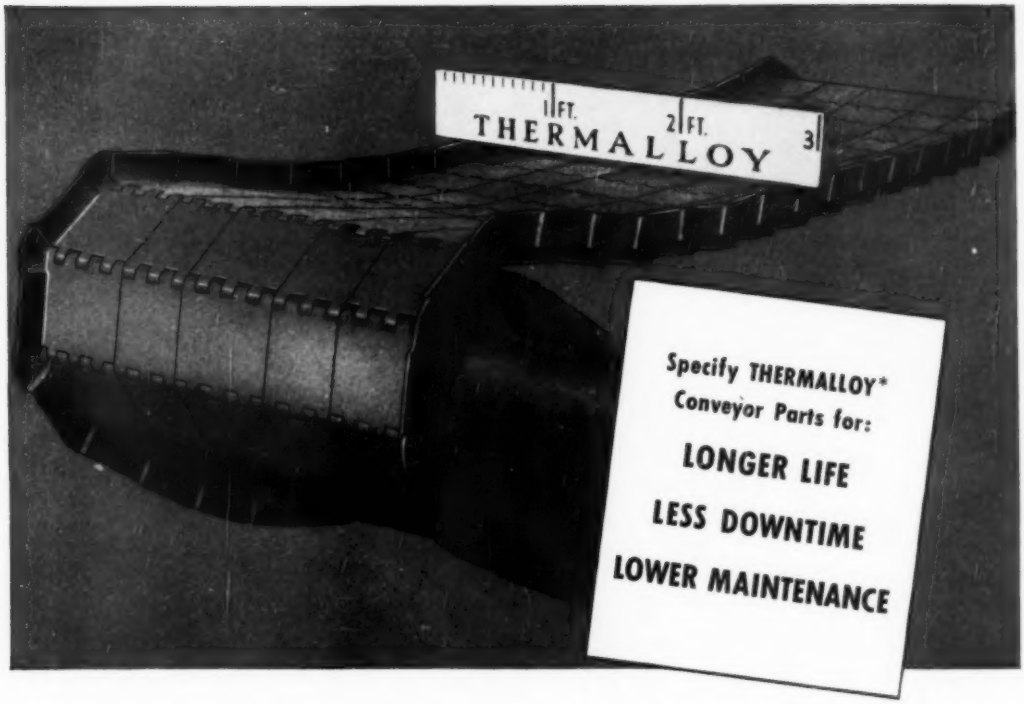
★ *May we quote on your requirements?*

THE FAHRALLOY COMPANY

CHROMIUM-NICKEL ALLOY CASTINGS FOR
CORROSION
HEAT
ABRASION

149th AND LOOMIS, HARVEY, ILL.

In Canada—Fahralloy Canada, Ltd., Orillia, Ontario



Looking For An Answer to Heat-Treat

CONVEYOR TROUBLES?

If you're bothered by these conveyor troubles:

- *Jumping the sprockets*
- *Pins "crank-shafting"*
- *Frequent replacement of defective links*
- *High maintenance cost*

. . . you'll find such troubles can usually be traced to improper engineering or inspection of the original conveyor parts.

For example, if dimensions on individual castings are not accurate, the driving drum or sprocket will exert an unequal pull on each line of links. This causes stretching. Pins often "crank-shaft". . . causing belt to "ride" on top of driving drum lugs, instead of engaging properly. This results in fracture of individual links and increased maintenance costs.

The cure for such troubles rests on careful engineering and production. Individual castings must be identical in length—so the belt will engage properly with driving drum, and no one link will be overstressed. Good design also provides close spacing between links for carrying small parts . . . and allows sufficient clearance to eliminate excessive wear.

Electro-Alloys has made a specialty of the precision engineering and production techniques required to produce conveyor belts of outstanding quality. We can show you *proof* that THERMALLOY high alloy conveyor parts give longer life, cut downtime and maintenance costs.

Call your nearest Electro-Alloys engineer. Or write Electro-Alloys Division, 1977 Taylor Street, Elyria, Ohio.

THERMALLOY resists temperatures up to 2200° F.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

FIVE PIECES

OPERATIONS

STAMPING
DRAWING
WELDING
MACHINING
FINISHING

ONE PIECE

OPERATION

DIE CASTING

DIE CASTING MACHINES

You are cordially invited to view the operation of the new Lester-Phoenix HP-1-Z zinc die casting machine at the Lester-Phoenix plant in Cleveland, during the Metal Show, October 17-21. Free transportation will be provided from the show to the plant and back. Look for the Lester-Phoenix station wagons.

☆ ☆ ☆ ☆ ☆ ☆

ONE of the most prominent radio manufacturers in the midwest recently made a survey of the parts going into its equipment from the point of view of reducing costs. One unit comprised of 5 parts involved stamping, piercing, drawing, bending, machining and partial plating and **then required 32 or more spot welds for assembly!** It was a matter of simple economy which convinced company engineers to turn to Lester-Phoenix Die Casting Machines which produced the unit in ONE PART! The elimination of all the above-mentioned operations reduced the cost appreciably. You owe it to yourself to check on how Lester-Phoenix equipment can effect major savings in your plant!

Write for your free copy of the Lester Press

LESTER-PHOENIX DIE CASTING MACHINES

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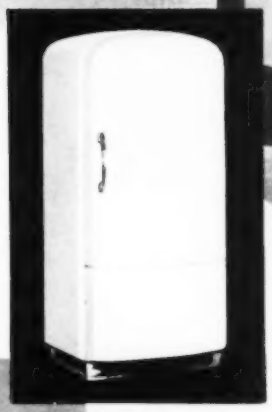
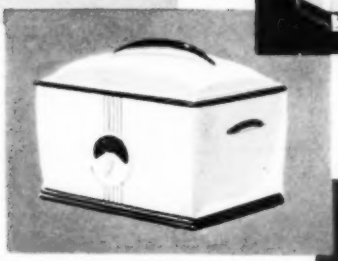




TAKES PAINT EASILY— HOLDS IT FAST

Paint stays put—and so do enamels, lacquers, varnishes and lithographic inks—on products made of durable Weirzin as supplied direct from Weirton in coils or cut lengths. Paint and other finishes, once applied, are there to stay—safe from the marring effects of underfilm corrosion, which just cannot occur in Weirzin. Its tight malleable zinc coating, electrolytically applied, is integrally bonded to the steel—to remain intact through manufacturing operations, and under all conditions of temperature and humidity.

WEIRTON STEEL CO.

WEIRTON, W. VA., *Sales Offices in Principal Cities*

Division of **NATIONAL STEEL CORPORATION,** *Executive Offices, Pittsburgh, Pa.*

Buehler...

METALLURGICAL LABORATORY EQUIPMENT

Operator using the new Model No. 1506 low speed polisher. Section of laboratory equipped with No. 1251 Duo Belt Sander—No. 1700 Electro Polisher—No. 1315 Press.

. . . provides the metallurgist with the most complete line of modern designed precision machines for specimen mounting and preparation available anywhere in the world. This finely made equipment has been developed through a thorough understanding of the requirements of the metallurgist and a rigid insistance on perfection in the mechanical design and construction of each item.

Everything needed for metallurgical testing from cut-off machines, moulding presses, and grinders to the mechanical or electrolytic polishers is included in the Buehler line.

In setting up complete laboratories or adding items to present equipment the metallurgists will find in the Buehler line of coordinated equipment everything needed for producing the best work, with speed and accuracy.

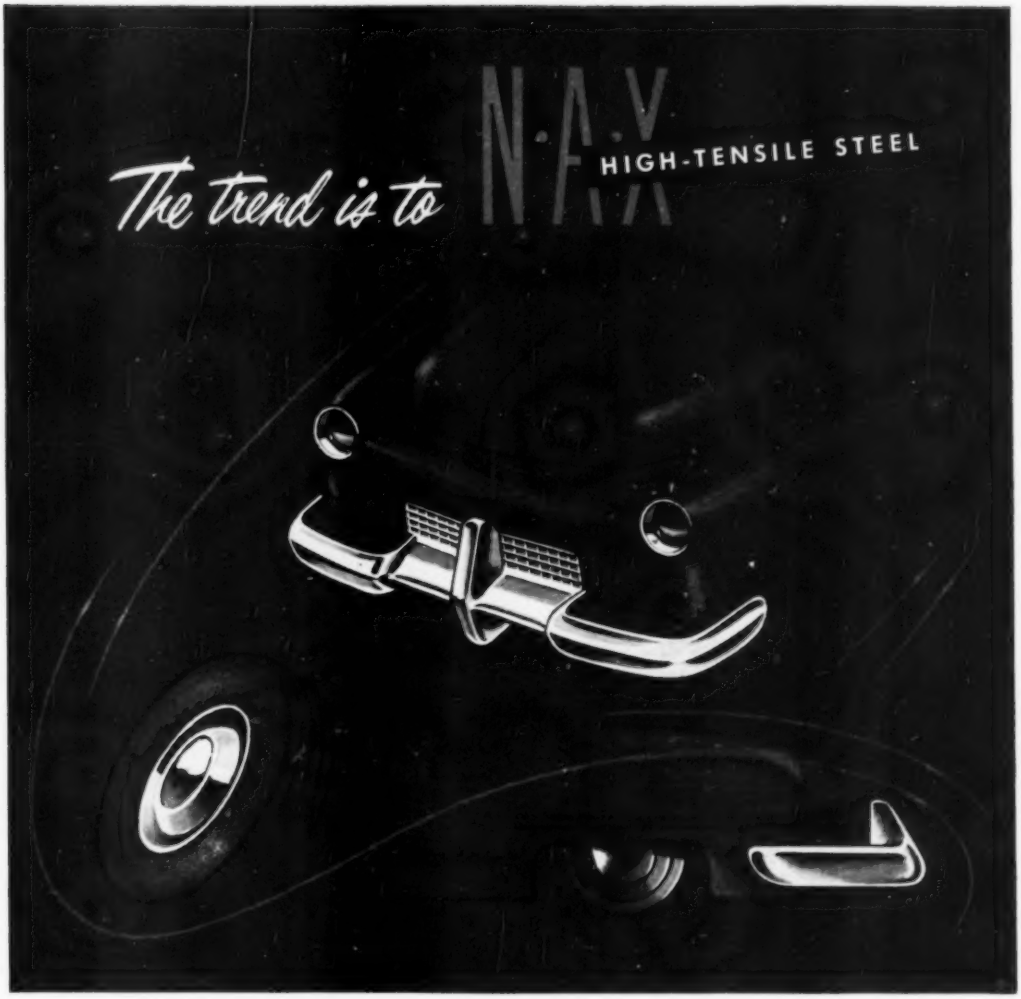
THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES

Write for bulletin of new equipment or information on any specific item. We invite correspondence relative to setting up complete laboratories suitable for any particular requirement.

Exclusive U. S. agents for Amsler and Chevenard Testing Machines.

Buehler Ltd.
A PARTNERSHIP

METALLURGICAL APPARATUS
165 WEST WACKER DRIVE, CHICAGO 1, ILL.



Since 1940, when Great Lakes Steel pioneered the application of high-tensile, low-alloy steel to cold-stamped automobile bumpers, there has been a growing trend to N-A-X HIGH-TENSILE steel in the automobile industry.

Today, every car manufacturer is using the inherent better properties of N-A-X HIGH-TENSILE steel for some part of his automobile.

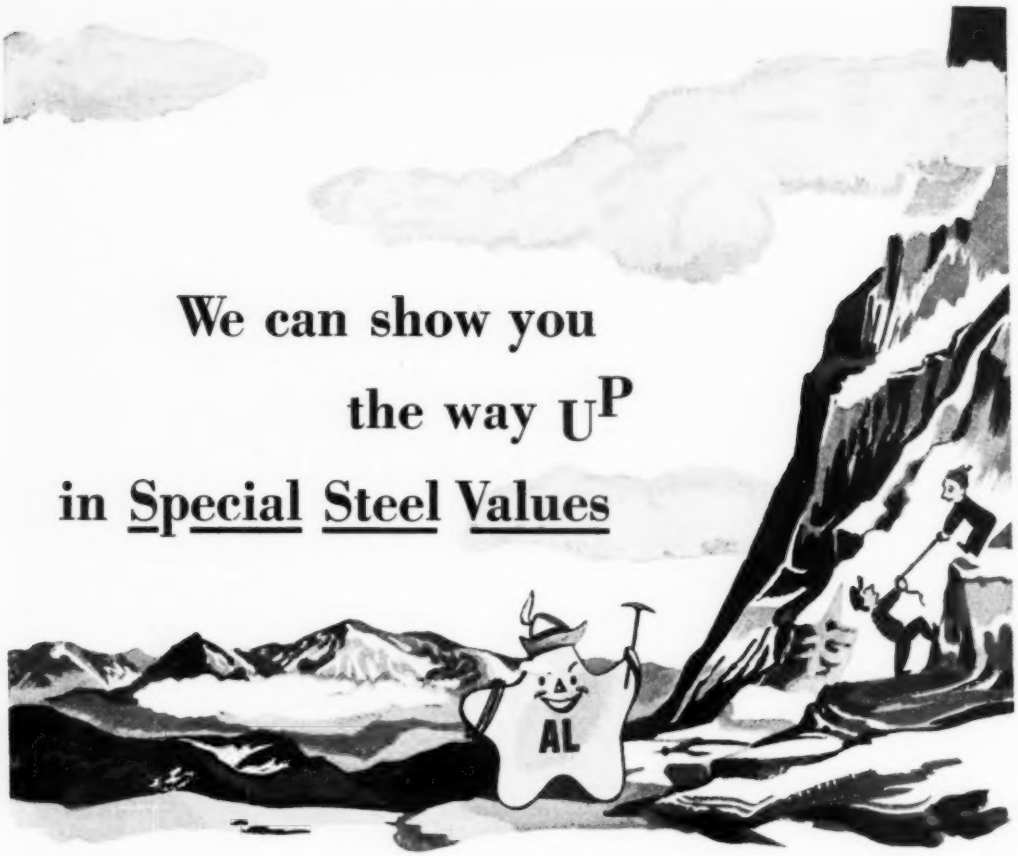
Bumpers and grilles—hoods and fenders—body panels and deck lids—frames and bracings—wheels and hub caps represent a few of many applications of N-A-X HIGH-TENSILE steel to the modern car.

MAKE A TON OF SHEET STEEL GO FARTHER
Specify N·A·X HIGH-TENSILE STEEL

N-A-X HIGH-TENSILE MEETS ALL REQUIREMENTS OF S.A.E. 950

GREAT LAKES STEEL CORPORATION N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN
Unit of National Steel Corporation

We can show you the way UP in Special Steel Values



The only real value in a material lies in what it will *do* for you. Will it improve the quality of your products—let you give more to the user at the price? Or, on the other hand, will it improve your cost position—help to keep open your vital area of profit?

When you begin to think about better materials, you're automatically in the field of special high-alloy steels—*and Allegheny Ludlum*. From the various AL families of stainless and heat-resisting steels, tool steels and sintered carbides, special high-temperature alloys and electrical materials, let us help you to select the metals that will yield the benefits you're looking for.

Just remember that the first cost of a special steel may be only a little, if any, more than the material it replaces—and it's usually many times cheaper in the long run. ● *Our Technical Staff is fully at your disposal.*

Complete technical and fabricating data—engineering help, too—yours for the asking.

ALLEGHENY LUDLUM STEEL CORPORATION

The Nation's Leading Producer of Stainless Steel in All Forms

AL

Pittsburgh, Pa. . . . Offices in Principal Cities

Allegheny Metal is stocked by all Jos. T. Ryerson & Son, Inc., Warehouses

Specimen of AIRCOMATIC welding stainless—vertical down.

now it can be done!

weld stainless steel with new high-speed AIRCOMATIC process

Now, stainless steels in all standard joint designs, in thicknesses of ⅛ inch plus, can be welded faster *in all positions.*

You can make single or multi-layer welds by either beading or weaving. Vertical welds can be made upward or downward. In short, the Aircomatic Process permits the welding of stainless with all the ease and versatility of ordinary steels – at a high rate of deposition and with complete freedom from slag.

Continuous feeding of filler metal, and inert gas (helium or argon) shielding, are the two main features that give this new welding method its exceptional speed and flexibility. A bare filler metal, in wire form, is fed continuously through a manually-operated gun . . . and, of utmost importance, the process deposits a weld metal with an analysis almost identical to the filler wire – even approximately 60% of the titanium in the filler wire is transferred to the deposited metal.

Investigate the many advantages this new *Aircomatic Welding Process*, for welding stainless steels, aluminum and other metals, can offer you. If you can't visit our booth at the Metal Show, but desire more information in the form of a descriptive folder, delivery and price data, fill in and mail the coupon below.

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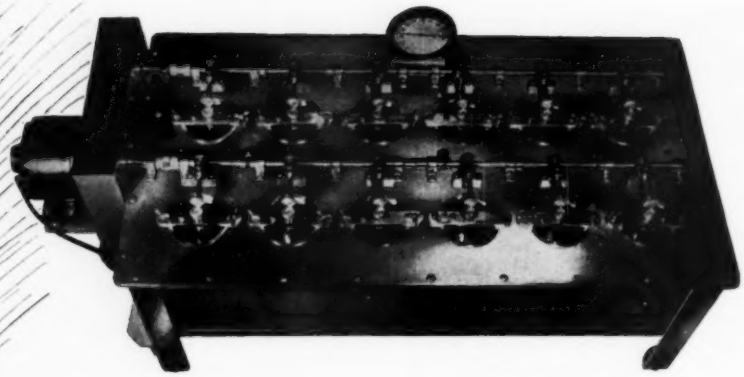

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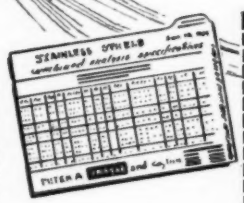

This new Frasse data chart A-7 supplements the usual stainless property data with a wealth of additional detail. It shows typical properties—tensile, yield, hardness, etc.—of bars, strip, sheets, plates and wire *in various stages of cold working or heat treating.* Invaluable for careful selection of best stainless steel for your application. Send for a free copy today.

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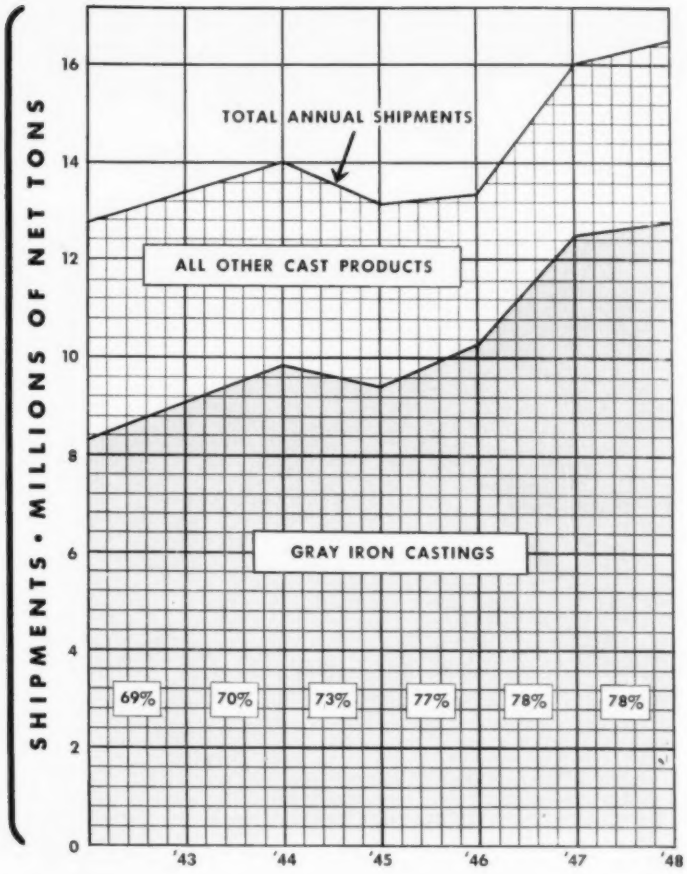

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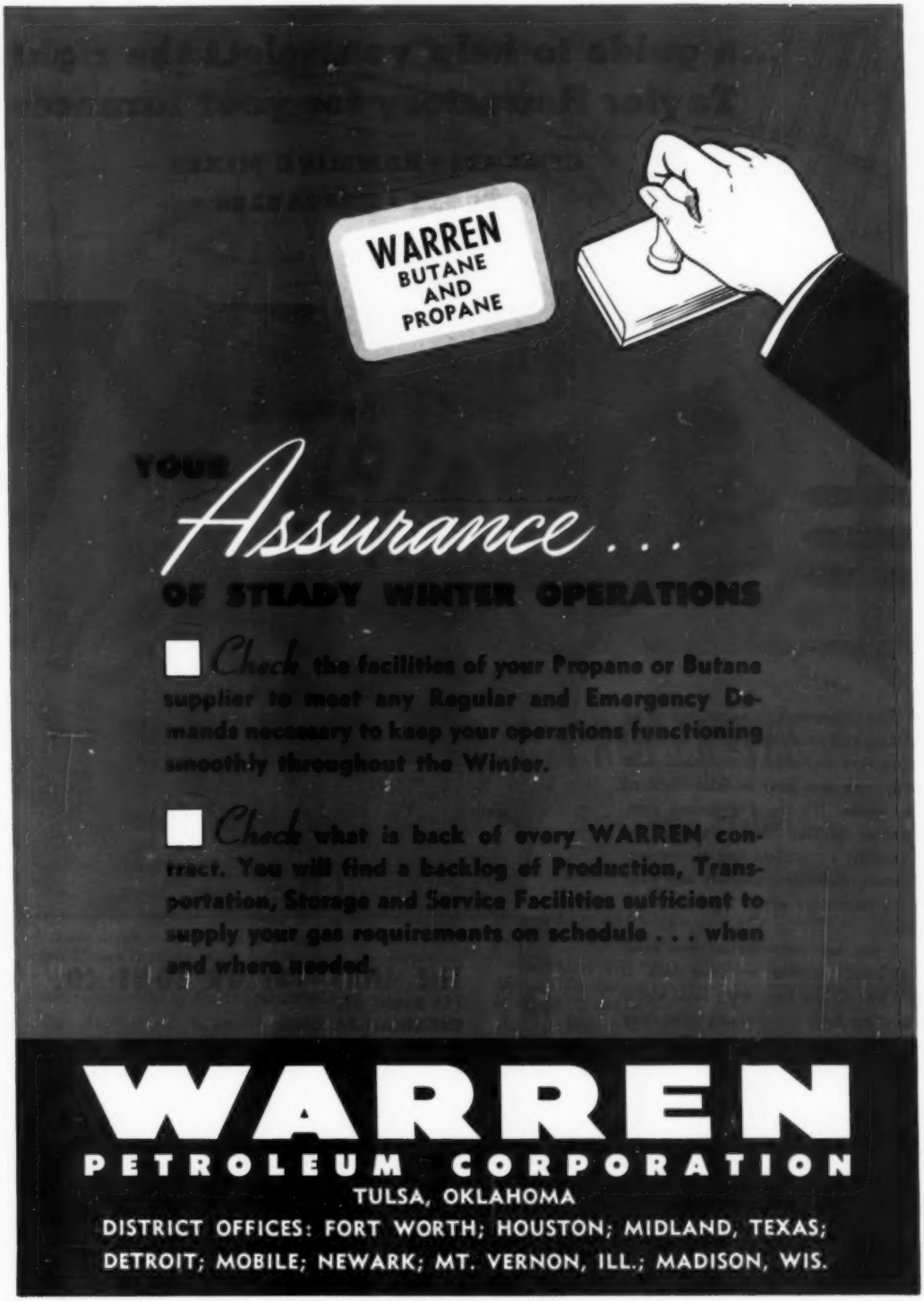
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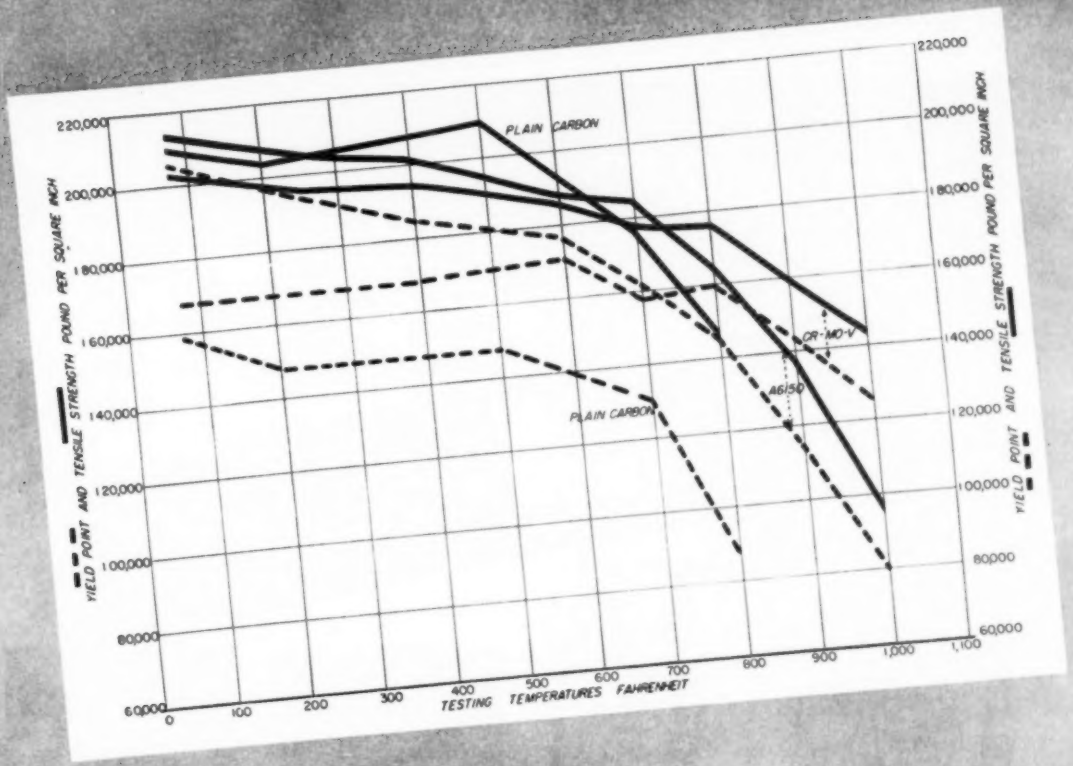

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SPRINGS FOR SERVICE at elevated temperatures require steels which resist softening and lowering of the yield point. Unless hardness and yield strength are stabilized by correct alloy additions to the steel, these properties deteriorate rapidly as the temperature is raised.

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Figure 1
Bliss Inclinable Press.

Figure 2
Large Bliss Toggle Press used for deep drawing operations.

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October, 1949

Volume 56, No. 4

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Metal Progress

Ernest E. Thum, Editor
Taylor Lyman, Associate Editor

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Economy in Production

SINCE the theme of the forthcoming convention and exposition of the American Society for Metals is to be "Economy in Production", it was fitting for the exposition management to offer some prizes for case histories showing how members of the Society have achieved economy in various metallurgical activities. The rules of the contest demanded quick action, brevity of presentation, and credit to men and plants.

The following 30 pages present a selection of the entries. They were extraordinarily varied in subject, indicating certainly that the members of the American Society for Metals are exerting a salutary influence on hundreds of details in metal manufacturing operations. First prize of $300 has been awarded by the judges to Leonard G. Daniels for his entry "Great Savings in Replacing Complex Assemblies by a Single Investment Casting" (p. 490); second prize of $100 to Charles R. Funk for "Chromium Reduction and Recovery From Scrap or Ore in Basic Openhearth" (p. 486); third prize of $60 to John F. Tyrrell for "Dies for Deep Drawn Objects Designed by Unfolding Final Shape" (p. 494); and fourth prize of $40 to J. C. Heymann for "Efficient Phosphating Compound for Cold Drawing of Steel Tubing" (p. 497).

Electric Furnace Melting —

Quality Control Creates and Maintains More Uniform Steel and Greater Production

By W. O. Igelman and F. S. Nussbaum
Metallurgist *Assistant Metallurgist*
National Malleable & Steel Castings Co.
Melrose Park Works, Melrose Park, Ill.

SINCE the end of World War II, National Malleable & Steel Castings Co., in applying quality control methods to new equipment and processes installed during the war years, has improved quality, uniformity and economy in its metallurgical practice. This improvement has influenced not alone the metallurgical department's results, but those in foundry and other operating departments as well.

A first step in achieving the desired goal consisted of installing quality control charts, recording trends of operation as observed by the metallurgical department. These charts indicated without question that the quality of the metal (principally intended for railroad castings) required improved metallurgical control. Toward this end, supervision was more concentrated, and the melting practice was improved; likewise, more extensive exploitation of the quality control methods was thought highly desirable.

Prior to the change in melting practice (indicated by quality control records) it was a common

occurrence to melt individual charges varying considerably in chemical content. The type of available scrap was mainly the cause of this condition; not much thought was given toward improving the charge, since little could be done at the time toward procuring better scrap. It was necessary, therefore, to vary the amount of ore additions to the different charges by as much as 200 lb., and the resultant fluctuations in the working conditions of the molten metal were reflected in erratic physical properties of the final steel. Standardization of charges and ore additions was therefore desirable and accordingly initiated. At this time no changes were made in the intended final analysis.

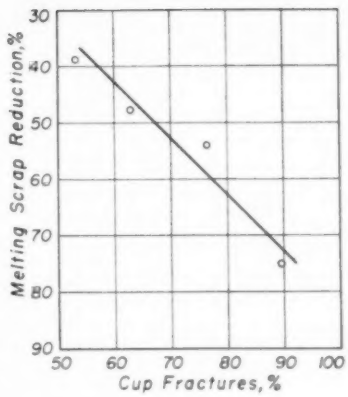
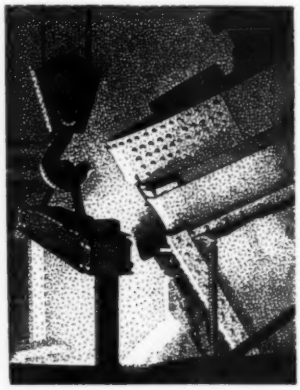


Fig. 1 — Relation Between Reduction in Melting Scrap and Cup Fractures Shows That Heats That Give Cup-and-Cone Fractures Have Cut Scrap to a Small Proportion of the Former Expectancy. Base of vertical coordinates: 100% = melting scrap produced in first half of 1948. Higher physical properties accompanied the reduction in melting scrap

In addition to keeping the average carbon content of the charges more constant by the use of select scrap (and also high enough to give a vigorous boil), it was decided to change the melting schedule itself. Up to that time, the greater portion of the slag was raked off after final additions had been made, just prior to tapping, and after adequate time for complete solution of the finals.

The slag was raked off at this point in order to avoid losing too much deoxidizer in the large volume of slag which would accompany the metal into the ladle during tapping; furthermore, ladle deoxidation of the metal would be difficult if this slagging had not been done. This practice also resulted in losing variable amounts of final alloying additions in the slag, thus causing unpredictable chemical variation in the metal. Off-analysis heats, which would require special heat treatments at additional expense, were not infrequent.



To overcome these difficulties it was thought desirable to remove the greater portion of slag immediately after the boil was completed and the block had been dissolved in the melt, leaving only sufficient slag to protect the metal surface from the atmosphere. The amount of slag remaining within the furnace at this stage of operation is nearly constant for all heats, and the slag present when tapping is neither objectionable in nature nor voluminous.

The results obtained from changes made in the practice were noted, correlated from quality control charts in use, and resulted in appreciable savings. The recovery of final addition agents in the metal was found to be higher and much more consistent than with the older method. For example, a savings of 3.5% of the silico-manganese was

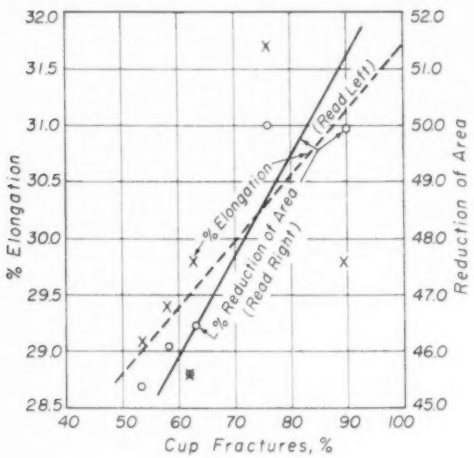


Fig. 2 — Quarterly Averages of Ductility Figures (Percentage Elongation and Reduction of Area) Correlated With Percentage of Cup-and-Cone Fractures

Table I — Cost Reduction in Melting Department

Quarterly Periods	Reduction in Cost, %			
	Labor	Electrical Power	Electrodes	Addition Agents
First, 1948	11.5★	10.6★	10.3★	—
Second				
Third	18.2	7.7	9.6	2.0
Fourth	26.8	18.2	11.5	3.9
First, 1949	23.7	15.1	11.2	1.8
Second†	10.0	—	4.5	3.3

realized on the average heat. It was found upon metallographic examination that undesirable chain-type inclusions, often encountered in the steel before the change, became considerably less frequent and soon were completely absent.

This highly favorable condition of the metal was reflected in continually improved physical properties. Further evidence that a change had taken place presented itself upon studying the heat treating efficiency and the percentage of scrap attributable to metal conditions. Where previously some poorly made heats required, for example, a tempering treatment and often a complete reheat treatment, a far greater percentage of heats now passed all physical requirements by a good margin after a single normalizing. This favorable accomplishment brought about a considerable savings in time, handling, fuel and furnace life, as shown in Table II.

Table II — Cost Reduction in Heat Treating Department

Quarterly Periods	Reduction in Cost, %	
	Labor	Fuel
First, 1948	15.1★	9.5★
Second		
Third	30.3	6.9
Fourth	33.3	20.7
First, 1949	36.4	31.9
Second	39.4	19.0‡

A basis for comparing the old and new processes was established by tabulating the type of fracture obtained when test coupons from each heat were broken during the tensile test. It is usually considered that the ductile type of cup-and-cone fracture is an indication of a well-made heat. This line of thinking was verified when it was observed that the frequency of the ductile fractures increased gradually, after the previously described changes had been made. This gradual improvement was paralleled by improved physical properties, both as to ductility and strength. Averages of all properties considered, summarized into quarterly periods for 1½ years, are found in Table III. The third quarter of 1948 should be considered as the demarcation period. It should be noted that the percentage of cup fractures together with yield strength, tensile strength, elongation, and reduction of area, have been gradually raised without changing the intended final analysis. At the same time, the percentage of scrap, directly accountable to poor metal conditions, has decreased noticeably (to one quarter its former amount) and the retreatments or additional treatments required have decreased to a very low figure indeed. Because of the improved chemical control of the melting practice, we never have heats now that are impossible to heat treat so as to obtain at least the minimum physical properties.

Summarized data for the melting and heat treating departments are presented in Tables I and II. These summaries, correlating the improved costs for the quarterly periods with the upward trend of physical properties tabulated in Table III and illustrated in Fig. 1 and 2, present evidence of improved practice and greater economy. It should be noted that all data have been adjusted in such a manner that fluctuations in cost of materials, labor or fuel, due to market conditions or wage adjustments, have been eliminated so as to obtain a comparable set of data.

Table III — Average Physical Data for Railroad Castings

Quarterly Periods	Tensile Properties				Cup Fractures	Reduction in Scrap Attributable to Metal	Reheat Treatments
	Yield Strength	Ultimate Strength	Elongation	Reduction in Area			
First, 1948	44,011 psi.	74,826 psi.	28.8%	45.6%	62.2%	—	14.5%
Second	44,487	74,481	29.4	46.1	58.3	—	13.7
Third	45,862	75,640	29.1	45.4	53.3	38.9%	12.2
Fourth	46,088	75,258	29.8	46.5	62.6	47.8	6.6
First, 1949	45,327	75,160	31.7	50.0	76.5	53.8	4.4
Second	45,415	75,458	29.8	49.9	89.6	75.1	1.1

★January to March, 1948, is used as the base period.

†Two-shift operation was begun; three shifts previously.

‡Furnaces were used 16 hr. and not fired during remaining 8 hr., thus requiring some additional fuel for heating up.

Alloy Recovery —

Chromium Reduction and Recovery From Scrap or Ore in Basic Openhearth

By Charles R. Funk
Chief Metallurgist
American Locomotive Co., Railway Steel-Spring Div.
Latrobe, Pa.

IN 1944 there was a vast quantity of chromium-contaminated scrap which was a burden on the market. The openhearths were unable to recover the chromium metal, alloyed in the scrap, and were thus experiencing a great financial loss, besides being downright wasteful of a very strategic alloy. Melt records from a number of shops indicated the normal recovery to range from 18 to 28% — that is to say, 72 to 82% of the chromium was lost as oxide (Cr_2O_3) in the slag. These figures clearly indicated the value of developing a furnace practice permitting a greater recovery of the alloy. We decided to establish such a practice at our Chicago Heights plant and immediately studied heats made with various amounts of alloy steel scrap of known composition. Slag and metal tests were taken approximately every 10 to 15 min. during melting and up to the time the heat was tapped. Slag tests were taken in the form of pancake tests and were analyzed for CaO, SiO_2, Fe, FeO, Fe_2O_3, MgO, MnO, Cr_2O_3, P_2O_5, Al_2O_3 and S. Thin slag sections were also prepared for petrographic study; metal tests were analyzed for C, Mn, Cr, Si, P and S.

From this work we soon concluded that if we could control the position of the Cr_2O_3 in the slag, we would be better able to promote its reduction. (Cr_2O_3 could be present as a separate spinel phase, or as part of the oxide phase of the slag, in "solution", so to speak.)

Melting data indicated that chromium acted similarly to manganese, in that a large percentage of it was oxidized during the early melting period. Further, it was known that Cr_2O_3 has a very strong tendency to react with the FeO in the slag or dissolved in the metal, forming what is known as a spinel, a mineral consisting of FeO, MgO, Al_2O_3 and Cr_2O_3, the main constituents being FeO and Cr_2O_3. Large quantities of this mineral caused the slag to be very thick and heavy and most difficult to work.

A correlation of the data collected with the aid of J. O. Griggs, openhearth superintendent, and L. W. McConnell, plant metallurgist, indicated certain trends, from which we deduced enough facts to warrant trying certain controls. By trial and error we were able to reduce the Cr_2O_3 in the slag to metallic chromium which migrated back to the metal bath. Seldom was the chromium recovery less than 70%; in fact, we aimed for 80 to 85%. During this time we were making a large tonnage of S.A.E. 8700 steels (the so-called "National Emergency Steels" with about 0.50% nickel, 0.50% chromium, and 0.25% molybdenum) and for one month's production averaged 83% chromium recovery. This represented an increased recovery of 60% over standard practice.

Furnace practice is described in U. S. Patents 2,422,299 and 2,464,302, the first covering the use of chromium scrap and the second the use of chrome ore as a source of chromium. The practice involves a controlled charge so as to obtain the desired lime, silica, iron oxide and a low slag volume, and a method of slag development by additions of deoxidizers such as lime, silicon, aluminum, carbon and fluorspar, so as to obtain reactions which will result in the ultimate reduction of the chromium oxide. It is advisable to use at least 60% burnt lime in the charge so that iron oxide and slag volume are low and the lime-silica ratio is not less than 1 at melt-in (preferably 1.4 and of the ice-fern type rather than the furrow-type slag). This in turn assures that most of the Cr_2O_3 is in solution in the oxide phase and very little of it in the form of chrome spinels, which are highly undesirable.

In the working period of the slag, basicity and bath temperature are gradually increased and the

iron oxide is kept low and often reduced. The above-mentioned deoxidizers along with a sharp flame are employed. A reboil is used at the proper time to assist in high temperature. The slag additions are made in such a manner that most of the Cr_2O_3 reduction occurs after the reboil. The block should be short with a minimum of silicon used.

Fundamentally the process requires minimum slag volume, slag control as to basicity and FeO content, high working temperatures, and the use of strong slag deoxidizers. To indicate the savings we quote the following for a 60-ton heat, using 1944 cost of chromium, 13¢ per lb.:

Chromium charged in the scrap, 735 lb.
Normal recovery, 23% = 169 lb.
New recovery, 83% = 610 lb.

If this heat of alloy steel were made from a charge of chromium-free raw materials, and the 610 lb. of chromium were to be furnished by an addition of 70% ferrochromium at a normal recovery of 70%, 870 lb. of chromium (1240 lb. of ferro) would have to be added. This addition would cost $1.885 per net ton at 1944 prices of ferro. The alternative, before the introduction of our new practice, would be to melt down chromium-bearing scrap, and lose most of the chromium in the slag; 441 lb. of chromium would have to be replaced by ferrochromium, costing $1.365 per net ton of steel on the above bases of prices and recoveries.

The success of our practice was far beyond expectations on heats recarburized either with pig iron or with graphite. (See Fig. 1 and 2 for typical heat logs.) It was therefore decided to try charging chrome ore instead of chromium scrap. 2000 lb. of ore containing 44% Cr_2O_3 was used for first trials; again, recovery was far beyond anticipations. The first eight heats made showed an average recovery of 77% Cr.

Figuring the ore at $36 per gross ton, we have the cost of contained chromium as 0.7¢ per lb. The 60-ton heat thus acquired 462 lb. of chromium, at a cost of $36 or 60¢ per net ton. If the 462 lb. were to be replaced by a furnace addition of 70% ferrochromium at a normal recovery of the addition of 70%, 660 lb. of Cr in 943 lb. of ferro would have to be added. Thus the actual savings over adding ferro is $1.43 − 0.60 = 83¢ per net ton.

Review these figures with present market prices of 70% ferrochromium and chrome ore and you will note that there is a far greater savings today than we had in 1944. A balance of all costs indicates that a saving of at least $1.00 per net ton can be made in the openhearth melting of alloy steels containing chromium — which in the course of a year would add up to a staggering sum.

Fig. 1 — Heat Log of a Graphite Charge, Using 45 Lb. Burnt Lime per Ton in Working Period. Chromium recovery 70.7%

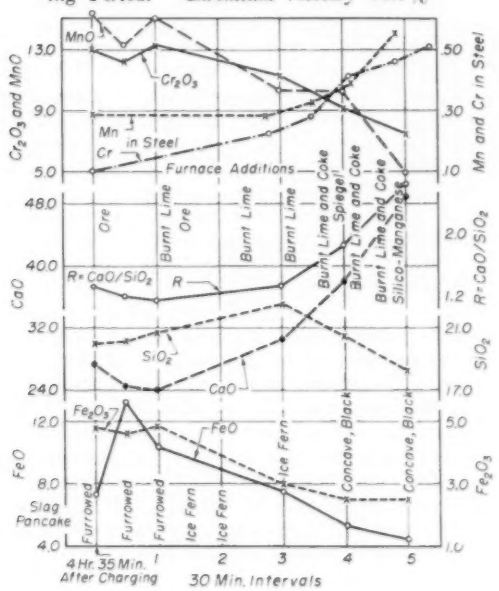
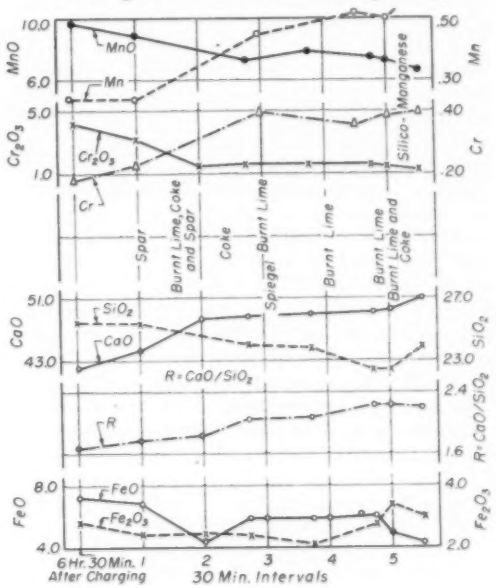


Fig. 2 — Heat Log of a Pig Iron Charge, Using 48 Lb. Burnt Lime per Ton in Working Period. Chromium recovery 81.5%



Rapid Analysis —

Recording Spectrometer Reduces Analytical Time 30-Fold and Speeds Furnace by 10%

ABOUT two years ago we reported the installation of a recording spectrometer, the "Quantometer", in *Metal Progress* (December 1947). It is now a pleasure to report that its operation surpassed all expectations. It not only speeded up the determinations of composition with considerable savings in cost, but also increased the accuracy of the analysis and — what is of greater economic value — eliminated lost furnace time and thereby increased production. Due to greater accuracy of analysis, we can make better use of available raw materials, a matter which is of great value in the smelting industry.

In our installation at the Apex Smelting Co. in Cleveland we are able to determine up to 18 elements simultaneously. The *range* is from 0.001 to 0.2% for some elements and 0.1 to about 15% for others. The *accuracy* at the outside is ±3% of the amount present. This accuracy is particularly good in low ranges, where speedy chemical methods usually are fairly inaccurate. The speed of analysis is 45 sec. The total time per sample per analysis — which includes sample preparation, running three furnace samples in duplicate, clerical work, and reporting — amounts to 20 min. The total time expenditure per element determination is 0.024 man-hours when the Quantometer is working at peak efficiency. To compute the savings this should be compared to 0.54 man-hours for chemical and 0.143 man-hours for spectrographic analysis. Since our previous analytic methods consisted of chemical plus spectrographic analyses, the comparison is 0.54 plus 0.143 or 0.683 man-hours against 0.024, or 28.5 to 1. Representative data are contained in the following statement from J. D. MacCall of our Cleveland spectrographic laboratory.

By Walter Bonsack
Director of Laboratories
Apex Smelting Co., Chicago and Cleveland

Quantometer Performance in November 1948

Control samples	14,646 determinations
Final samples	10,629
Received material	6,772
Research	373
Calibration standards	8,274
Total	40,694

Comparison of the above figures with the chemical and spectrographic methods one year ago will show a striking increase in efficiency:

Man-hours required for determination:		
Chemical	0.54	Nov., 1947
Spectrographic	0.143	Nov., 1947
Quantometer	0.024	Nov., 1948
Determinations made per man-hour:		
Chemical	1.85	Nov., 1947
Spectrographic	7.00	Nov., 1947
Quantometer	42.50	Nov., 1948

Speed of analysis, then, has definite bearing on speed of production. By the previous methods every furnace had 1½ to 3-hr. waiting time per heat for final check analysis before it would be poured off. These lost hours can be eliminated completely, or in exceptional cases reduced to less than ½ hr. Depending on the number of furnaces in operation and the price put on one furnace-hour the savings are evidently considerable. In fact, if 10 furnaces are operating, the time saved is equivalent to having one more furnace.

Analytical control starts before the material gets into the furnace. Incoming raw materials can be and are sorted quite often. Small samples can be cut from questionable pieces of reclamation scrap and completely analyzed (or only typed as to alloy) in 40 and 10 sec., respectively, per sample. This cannot be done by other means with the same speed and accuracy, yet it is valuable to the buying, receiving, and production departments.

During the making of the heat, every charge of raw material can be checked immediately, allowing quick adjustments. Finished heats can be checked for uniformity before pouring and again during pouring. When the last ingot is

poured and stacked, the analysis of the heat is also finished and, except for other physical inspection tests, the heat is ready for shipment. All these factors are of great value to the production department. Due to the constant checking of the furnace charge, the uniformity of the metal is vastly improved, and with it the quality as well.

The advantages shown above were so well appreciated by management that another installation was authorized in our Chicago plant.

More Accurate Castings —

Mercury Pattern Solves Production Problem for Part Requiring Accurate Interior Surfaces

ONE of the instruments manufactured by the Sperry Gyroscope Co. contains a rectangular channel with copper walls ⅛ in. thick. Inside dimensions are 1.877 and 0.877 in., both held to +0.000, −0.003 in. It is shaped like a capital J, the straight end being 6 in. long and the curve bent to 1.281 ± 0.003 in. on center line radius. The inside corner fillets are $\frac{1}{64}$ in. max. radius. The specifications also call for a smooth surface on the inside.

A number of metalworking firms were contacted and only one was willing to try the job but could not guarantee the results. It was then decided to cast the part, using the patented "Mercast" process, a precision casting process wherein the mold, instead of being made of wax, is frozen mercury.

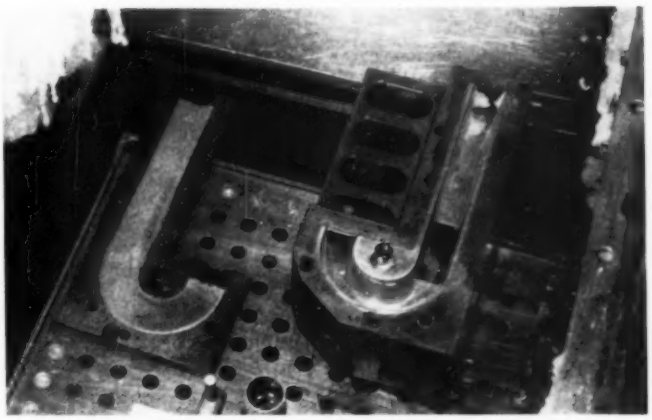


Fig. 1 — Mercury Patterns in Open "Core Boxes". The pattern is in two parts; the flat section at left is pressed on top of the channel to form the complete J-shaped tube, and the complete pattern then extracted from the right-hand "core box"

First, permanent molds similar to core boxes are made very accurately of metal. Their size makes allowance for solidification shrinkage of the final copper casting. These are filled with liquid mercury and frozen in a cold box. Figure 1 looks into such a cold box and shows "core boxes" whose covers have been removed; the one at the right contains the mercury "pattern" for bottom and two sides of the required casting and the one at the left contains the "pattern" for the flat cover of this J-shaped casting.

These two parts are extracted carefully from their boxes, assembled, riser pattern attached and the assembly coated inside and out with a layer

By L. T. Schakenbach
Precision Casting Engineer
Sperry Gyroscope Co., Great Neck, N. Y.

Fig. 2 — Casting, Riser Attached, as It Appears After Shake-Out. The small piece at left has been cut from another casting to show the smooth interior surfaces and the sharp corners required for proper functioning

about ½ in. thick of fine-grained refractory material. All this work must be done at temperatures below −38° F., the melting point of mercury; the refractory must obviously be "self-setting" in the sense that it becomes sufficiently rigid and can "dry" at those low temperatures.

After subzero holding, the mold is exposed to room temperature, the solid mercury replica of the finished casting melts and the mercury drains out, leaving a hollow refractory mold. This mold is subsequently dried and fired prior to casting.

Upon casting, the refractory mold is bedded in sand and preheated to 1000° F. Electrolytic copper is melted in a 20-kw. induction furnace under powdered charcoal. When the metal reaches the pouring temperature of 2200° F., the charcoal cover is skimmed off and a little phosphor-copper is added for deoxidation.

The casting is shaken out carefully and cleaned. The dimensions of the channel vary from 0.000 to −0.010 in. of specification and the radius of the bend is held within tolerance. The saving in making the part by casting instead of bending a square tube is estimated at 35%. Also, satisfactory finish and dimensions are insured.

Eliminate Machining —

Great Savings in Replacing Complex Assemblies by a Single Investment Casting

By Leonard G. Daniels
Metallurgical Engineer
Precision Metalsmiths, Inc.
Cleveland

INVESTMENT casting has received much publicity as a method of manufacturing precision shapes very difficult to machine, for turbosuperchargers and gas turbines. However, within the last three years the utility of the process has been widely extended. Such companies as Thompson Aircraft Products, General Electric, Chicago Pneumatic Tool, and Warner & Swasey rely on it for cost-saving production of intricate parts of industrial machinery.

One of the advantages of the investment casting process is that parts can be made from high alloy material. Yet a great variety of metals can be cast by this method; Precision Metalsmiths, Inc., has cast 68 different ferrous and nonferrous alloys, including the ordinary industrial alloys and the "superalloys" of jet engines. There are few indeed of the commercial alloys or steels that cannot be readily manufactured into parts of such precision as to require a minimum of machining, and of such intricacy as to reduce assembly costs sharply.

A typical instance of economy in production is shown by Table I and Fig. 1. The part is a

Table I — Operations for Shuttle Lifter

Number	Part	Operations	Cycle Hours	Setup Hours
	Old Method of Machining Subassemblies			
1	Lifter body	7	0.255	0.148
1	Upper plate	20	0.390	0.388
1	Lower plate	20	0.300	0.316
1	Plate	9	0.235	0.168
1	Pad	8	0.145	0.124
4	Lock washer			
4	Cap screw			
	Subassembly	1	0.060	
13		65	1.385	1.144
		Grand total		2.529 hr.
	New Method of Machining Single Casting			
1	Lifter	8	0.260	0.164
			Total	0.424 hr.
		Savings		
12 parts		57 operations		2.105 hr.

Table II — Operations for Shuttle Feeder

Number	Part	Operations	Cycle Hours	Setup Hours
	Old Method; Machining and Riveting			
1	Plate	10	0.200	0.112
2	Guides	10	0.220	0.120
		10	0.220	0.120
1	Block	10	0.310	0.128
1	Block	8	0.160	0.096
15	Rivets	1	0.075	0.040
	Subassembly	1	0.190	0.012
20		50	1.375	0.628
		Grand total		2.003 hr.
	New Method of Machining Single Casting			
1	Feeder	4	0.069	0.028
			Total	0.097 hr.
		Savings		
19 parts		46 operations		1.906 hr.

shuttle lifter, a component of a weaving machine made by the Warner & Swasey Co. of Cleveland. (The work sheet comparing the old method of production to the new was secured from its engineering department.) Redesigning the part for precision casting eliminated bosses necessary for assembly of the five parts with cap screws; eliminated also were 57 machining operations at a saving of 83.2% of the machining and setup time.

Table II is an additional exhibit of a shuttle feeder, another component of Warner & Swasey's weaving machine. In it, five parts and 15 rivets have been combined into one casting with the elimination of 46 machining operations and the saving of 95.2% of the machining and setup time.

Further savings, not evident from the tables, are obvious. Costs of stock handling, both in production and storage, are greatly reduced. Also, administrative costs (routing, billing, inventory) are appreciably lessened. And weight is saved.

The finished castings are extremely sharp in detail. Dimensions are held to 0.002 in. plus or minus in parts of this size. Parts with holes as small as 0.017 in. diameter are being cast in production by Precision Metalsmiths, Inc. Tests show that investment castings are superior to sand castings in physical properties and sometimes excel steel forgings of the same standard analysis.

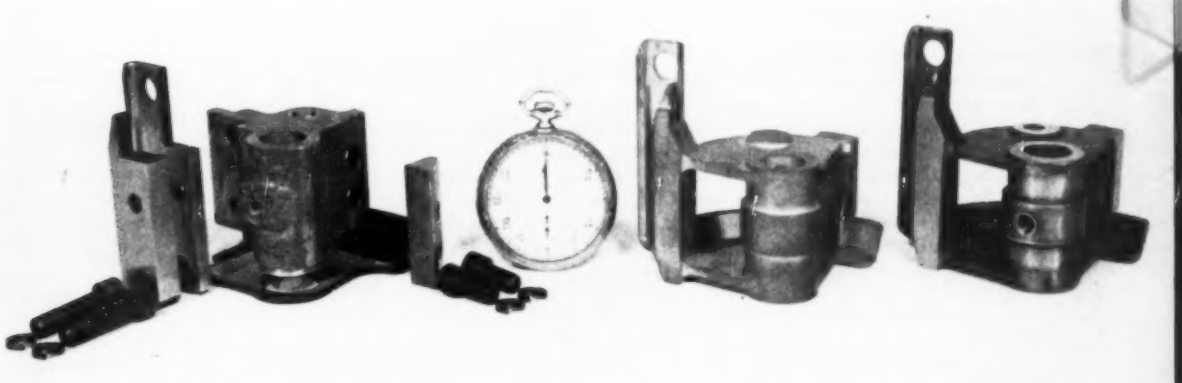


Fig. 1 — Fifty-Seven Machining Operations and 83.2% of Production Time Eliminated by Combining 13 Parts Into Single Precision Casting. Left: Disassembled parts of shuttle lifter. Right center: As-cast. Extreme right: Finished casting. (Watch, for comparative size.) The part is made of air hardening toolsteel

Drop Forge Dies —

Hard Chromium Plating Cuts Costs of Die Sinking

By S. L. Scheier and R. E. Christin
Forging Superintendent *Chief Metallurgist*
Columbus Bolt & Forging Co.
Columbus, Ohio

CONSIDERABLE savings can be effected by the depositing of hard chromium upon the face of drop hammer forging dies. It has been proven by actual production tests that wear resistance can be increased, die life extended, and flash line thickness controlled by this innovation — most certainly an improvement in production economy.

Forging die failures include *(a)* die checking, caused by overheating, *(b)* fatigue cracking, caused by stresses in deep cavities, *(c)* fatigue failures, caused by improper fitting between die and die holder, and *(d)* abrasion, caused by the flow of hot steel over the die surface. It is the rate of this die wear, or "wash", that is minimized by hard chromium plating. The first three types of failures mentioned cannot be overcome by plated surfaces.

It is therefore quite obvious that dies with deep cavities, sharp corners, or projections, which show any fatigue cracking, should not be plated. These failures are not the result of abrasion. On the other hand, it has been proven that there are many shapes of forgings where the die impression is such that plating with hard chromium will prevent early die wear. For example, forging dies for tin snips and kitchen shears, wrenches, pliers, tableware, turbine blades and other thin forgings are excellently suited.

The final finish impression has a certain amount of clearance, called "flash" and "gutter", as shown in Fig. 1. While being worked in this die to final shape, the excess hot metal flows out of the impression, after the cavity at a local section has filled but the shape requires further reduction to bring it down to size. (The forging in preliminary stages has unequal distribution of metal, and has not been preshaped sufficiently to suit the different sections.) Severe "wash" will be encountered as the metal is forced out through the flash. The smaller the flash opening, the more compression will the forging undergo, and the more improved will be the final quality; however, the more pressure applied the more the die will wear at this point.

Although such wear is not too important in large forgings, it is very undesirable in small forgings, because it is here that the excess metal or flash must be trimmed. To keep the forging from bending or twisting in cold trim operation, it is desirable to keep the flash as thin as possible. After the die has been used for some time, the other dimensions may not have changed appreciably, yet the flash has increased or "washed" to the extent that the die will have to be reworked, either because the forging cannot be satisfactorily trimmed or because there is too much metal escaping through the flash, thereby preventing the die impression from filling satisfactorily.

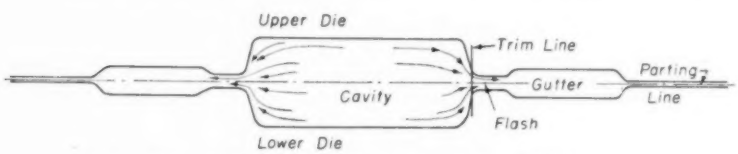


Fig. 1 — Cross Section of Drop Forge Dies at the Finish Impression

The face of a worn-out plier die is shown in Fig. 2. It has been marked with chalk arrows where the volume is less than at any other section, and where the wear has been most severe.

Fig. 2 — Worn Out Die for Pliers. Chalk marks indicate where the cross section of the forging is a minimum, and where the movement of hot metal (and "wash") is most severe

Fig. 3 (Center) — Proof Cast of Die for Kitchen Shears Which Produced Three Times as Many Forgings as Normally Expected, by Virtue of Four Trips to the Chromium Plating Tank

In Fig. 3 is shown a proof cast of a die for kitchen shears. On experience, this had been estimated to give a certain number of forgings per sinking. With sections of such irregular shapes, there is considerable hand work required to sink the die, therefore it is quite costly. When this one was placed in production, it was discovered after a run of only 10% of its estimated life that the die would wear rapidly at the flash line and make only half as many forgings as expected. At this point, hard chromium plating was suggested, since the shape of this forging so well suited the application. The die was then plated (by Master Chrome Plating Co. of Cleveland) approximately 0.0002 in. thick. The first plating was *after* 10% of the estimated die life; the second plating, after 50% of the estimated die life was spent; the third plating at 120% of the estimated die life, and the fourth and last at 200% of the estimated die life. The die was kept in service until 300% of the anticipated die life had been reached!

The savings (by four platings, as calculated from the estimated die life) were two sinkings. In dollars:

NOT PLATED	
Estimated costs of two resinkings	$1000
PLATED	
Costs of four platings and repairs	200
Total savings	$ 800

This amounts to 80% of the costs otherwise to be endured. Other experiments have substantiated these ideas. For example, one half of an open-end wrench die was plated with chromium, and a comparison was made with the other (unplated) half by measuring the wear at the flash lines of the two halves. Results are shown in Fig. 4. (Some wear took place on both dies before plating.)

Again, a set of tin snip dies that had been plated when new (since it was felt that no sticking would occur) produced 50% of anticipated die life at the first plating, and 100% of estimated die life on the second plating. By its present appearance it should produce 200% of anticipated die life without further plating. The cost of one plating was approximately 10% of the cost of one sinking, or 5% of two sinkings. Since it would require two sinkings

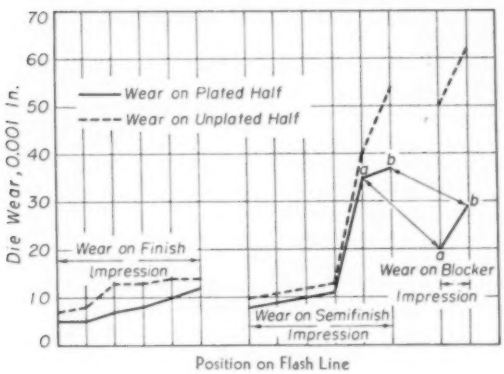


Fig. 4 — Average Wear on Identical Spots on Flash Line During Life of Open-End Wrench Die. At points "a" and "b" the die was left in production after the plating had worn, yet it was intact on the other sections of the die. These shoulders are much more exposed to wear than other sections, as shown by the severe wear of the unplated die at these same regions (connected by arrows)

without plating to produce the same number of forgings as one sinking and four platings, the costs should be based on the latter, and would show that 30% of the die sinking costs could be saved by chromium plating.

It is easy to judge when it is necessary to replate. Merely swab the die with copper sulphate solution. Where the chromium has worn through, the die will be attacked and red copper deposited, and the protected portion will remain steely white.

We have therefore concluded that there are two deciding factors as to the type of dies that can be plated at a savings:

1. Chromium plate only those dies which are giving excess wear; mainly, at the flash line.

2. Chromium plate only those dies of a design where cost of one sinking is equal to, or greater than, the costs of at least two platings.

Progressive Stamping Dies —

Dies for Deep Drawn Objects Designed by Unfolding Final Shape

By John F. Tyrrell
Research Metallurgist
Solar Aircraft Co.
San Diego, Calif.

IN SCHEDULING the fabrication of complex sections required in many aircraft components, the question often arises as to whether it would be cheaper to make a small number of extremely complex parts or to make a large number of easily formed pieces and weld them together. It would appear, on the face of it, to be more economical to produce only a small number of parts and eliminate as much welding as possible; however, complex parts require intermediate stages (dies), and annealings, and often the high number of rejections through cracks outweighs the savings realized by less welding. In addition, it may be necessary to use a material of heavier initial thickness so that the designed gage may remain in those areas of the pressed article where excessive thinning occurs during the forming operation.

For example, in some sections of the engine exhaust system of the Boeing B-29 Superfortress, the initial gage thickness had to be 0.078 in. for a final required thickness of 0.050 in. throughout the section. When these same sections were produced at Solar Aircraft Co., using the stage die method described below, the initial sheet thickness was reduced to 0.063 in., and the thickness tolerances were easily maintained. Savings resulted not only of 20% in expensive metal's first cost, but also in several pounds in the final weight of the aircraft.

The process to be described, as originally

Fig. 1 — Set of Four Stampings Showing Progression to Shroud Section With Nearly Vertical Sides

conceived by its inventors and patentees, Lewis E. Burger and Jennings B. Skinner, was developed as a simple, inexpensive, and nonmathematical method of preparing stage dies for the fabrication of the complex shapes found in aircraft components of sheet metal. Because their idea was based on the premise that the metal blank should be allowed to flow naturally, rather than be stretched or pushed into the desired shape, the result has been that sections previously considered too difficult and costly to produce are being formed daily with a negligible rejection rate, and without the need of costly interstage annealing. It is common knowledge that parts deep drawn of steel sheet have given much trouble. Breakage in dies at times reaches intolerable proportions, and causes extensive changes in dies, steelmaking processes, losses in production time, and general unpleasantness. Our successful experience, therefore, is capable of far wider extension than merely in the airframe, airengine, and accessories industry.

Only the design of the final shape is required to produce the necessary dies. In other words, we progress *backward* from finished form toward the flat starting blank, rather than in the opposite method of attacking the problem. From the final shape — it may be in wood — a plaster pattern is prepared in the usual way. This final plaster pattern is covered with a water-soluble slip coat. Molten beeswax and cheesecloth are then applied in successive layers until about $\frac{3}{32}$ in. thick. The threads of alternate layers of cheesecloth are usually offset 45° from each other. When this wax and cheesecloth replica of the desired stamping is cool and stiff, it is readily removed from the plaster by lifting the edge and allowing water to dissolve the slip coat.

The replica thus formed, while flexible, is substantially nonstretchable and nonshrinkable. A representative shape is illustrated at the bottom end of Fig. 1. It is next unfolded or flattened out the desired amount (thought, by experience, to represent a safe change in contour of the metal) and held in such position with clay bolsters until it has been backed with about 2 in. of plaster reinforced with jute fiber. When this has solidified, the pattern is inverted, tilted to its best position with respect to the modeling table — representative of the hammer bed — and bolstered with clay. This forms the matrix for the "Sol-A-Die" pattern, so-called — in Fig. 1 it is the pattern for the next to last stage.

When more than one stage appears to be desirable, the process is repeated. The original pattern may be reused by unfolding it further, but it has usually been found more satisfactory to mold a new wax on the intermediate stage pattern just completed.

Figure 1 shows the successive stages used in the fabrication of the forward exhaust shroud section of the Lockheed P-38. It is obvious that the first stage (top of photo), in which all the stretching and drawing is completed, is comparatively shallow and readily formed. The successive stages illustrate how the metal is gradually folded into the final deep shape with nearly vertical sides. In the original fabrication schedule for this section, only the final die was used, and even with the most skilled operators the rejection rate was 80%! Material was Type 321 stainless steel (18-10 Ti). When the three preliminary dies were made in the manner described, the rejection rate dropped to less than 5%.

Since this shroud section is a really difficult part to form, this same die set shown in Fig. 1 has been used to evaluate the formability of many of the newer alloys developed for elevated temperature service in jet engine components. It has been found that most of these alloys — for example, N-155, 19-9DL, S590, Inconel X, L605, and S816 — can be formed readily into this shape without interstage annealing. Even "Vitallium", a cobalt-base alloy with extremely low ductility, has been formed successfully in this set of dies,

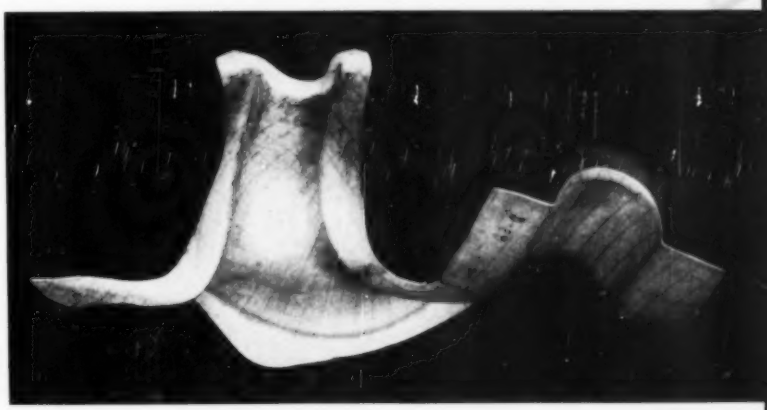


Fig. 2 — Rectangular Grid, Placed on Flat Blank, Shows How This Exhaust Manifold Part Has Been Formed Without Excessive Stretching at Any Place

although it is necessary to anneal the alloy between stages.

In Fig. 2 is shown one section of the B-29 engine exhaust manifold which originally had been built from several parts welded together. Dies for it were developed in the manner just described. The savings realized on this part, made as a unit, include reduction in costs of numerous blank cuttings and trimmings, in forming one part instead of several, in the elimination of welding, and in the amount of bookkeeping necessary to keep track of the "extra" pieces. Examination of present condition of the rectangular grid marked on the blank from which this stamping was made indicates how the deformation is uniformly distributed over the entire area and that even in the vertical section the grids remain nearly square.

Economies realized by the use of this process at Solar Aircraft Co. have been apparent in the manufacture of more than $30,000,000 worth of sheet metal stampings made from a variety of alloys, including austenitic stainless steels, many of the newer superalloys for jet engine parts, various aluminum alloys, and low-alloy steels.

Cleaning Forgings —

New Method Cleans Miscellaneous Forgings Cheaper Than Pickling, Tumbling and Sandblasting

By L. J. Wieschhaus
Mishawaka, Ind.

Cleaning Equipment With Open Door Showing Load of Forged Wheels Ready for Discharge Into Tote Box Between Machine and Charging Skip

THIS entry into the Economy-in-Production contest describes savings in the cleaning costs obtained by Unit Drop Forge Division of Fuller Mfg. Co. of Milwaukee, as a result of a change in cleaning methods. The data were obtained through the cooperation of George Houting, purchasing agent, and M. Gettleman, plant engineer, of the subject company. A photograph of the present installation is included. Since this is a jobbing forge shop, it would be difficult to give a detailed description of the work cleaned; perhaps it will be sufficient to say that the size and character of the product are the same now as prior to installing the new cleaning equipment.

Operation Involved — Cleaning forgings ranging in weight from 1 lb. to 100, and from 6½ to 37½ in. in length.

Economy Effected — Cleaning costs reduced from $3.194 per ton to $1.635 per ton, saving $1.559 per ton; $1559 per month on an average of 1000 tons of forgings; $18,708 per year.

How Economy Was Effected — Changing cleaning method from pickling supplemented by tum-

bling and sandblasting, to airless abrasive blasting.

Data for Previous Method:

Equipment used: 5 pickling tanks
2 tumbling barrels
1 airblast table
Production: 1000 tons per month
Time required: 16 hr. per day
Labor required: 64 man-hr. daily
Cost per month:

Labor	$2,561.20
Acid	440.00
Broken bottles, etc.	10.00
Pickle tanks	37.50
Pickle boxes	62.50
Outside cleaning	83.00
Total	$3,194.20

These figures do not include power costs for the air blast table or the tumbling mills. Neither do they include maintenance labor, repairs or supplies for this equipment. Accurate figures on these costs were not available. They do include the cost of cleaning by subcontractors, required to keep up with production.

Data for Present Method:

Equipment used: 48 x 42-in. "Wheelabrator Tumblast"
Production: 1000 tons per month
Time required: 16 hr. per day
Labor required: 16 man-hr. daily
Cost per month:

Labor	$ 606.00
Abrasive	379.00
Power	100.00
Parts	200.00
Maintenance	350.00
Total	$1635.00

This represents a saving of $1559.20 per month or $1.559 per ton. The change in cleaning method resulted in one other important advantage, namely, it solved the troublesome problem of disposing of the waste pickle liquor.

Drawing Die Lubricant —

An Efficient Phosphating Compound Preparatory to Cold Drawing of Steel Tubing

PHOSPHATE coating as an aid to the cold drawing of steel tubing and other shapes has been definitely established. Its benefit has been verified by research in many plants of this country as well as in Germany.

For two years prior to November 1947, the Gambrinus cold drawing department of The Timken Roller Bearing Co., Steel and Tube Division, has used a commercial phosphating compound with gratifying results as compared with years preceding this period. Vigorous competition between manufacturers of various phosphating compounds had warranted an investigation and an attempt to effect better production, economically or otherwise — a result that was actually achieved, as will be evident.

At the beginning of the trial period a five-month testing program established the merit of a product called "Banox", made by the Calgon Co. of Pittsburgh. It is a dry hydroscopic compound comprised mainly of aluminum joined to a phosphate radical which (in aqueous solution) produces an amorphous vitreous coating on clean, pickled steel, derived entirely from constituents of the solution. Approximately 3.5% of the powder is commercial sodium dichromate which acts as a solution activator and a metal depolarizer, thus facilitating the electrochemical deposition of the phosphate coating.

The solution is prepared simply by mixing 12 lb. of powder in 100 gal. of cool tap water. The solution should be slightly air-agitated during use and kept below 120° F. The strength of solution is in the order of 0.75 to 1.50% "Banox",

By J. C. Heymann
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Steel and Tube Division
The Timken Roller Bearing Co., Canton, Ohio

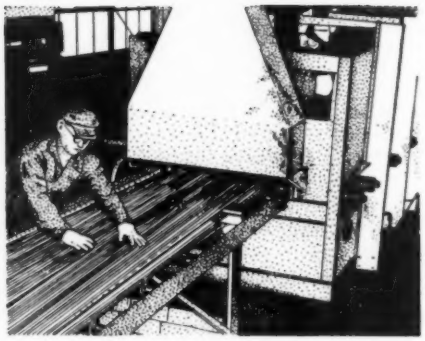
400 to 600 parts per million dichromate; its pH range is 3.5 to 4.0. Solution strength is maintained by simple weekly routine chemical analysis and appropriate additions.

During the first two months of testing at Timken, the stock's corrosion resistance and the lubrication effected in the cold drawing operation were of chief concern. Two extreme grades of steel were corrosion tested, namely, S.A.E. 1015 and 52100. Test pieces were all 2¼-in. tubes, 10 in. long. A lot of 10 pieces was prepared for corrosion testing each steel as follows:

Ten annealed tubes with hot rolled finish had a 10-in. piece cut from the end; the pieces were hot pickled in 10% H_2SO_4 solution, rinsed in cold water, and then treated in pairs. The first pair was phosphate coated with the formerly used compound and then rinsed in cold water; the second pair was coated the same, but not rinsed in fresh water. The third pair was treated with the "Banox" solution and rinsed; the fourth pair was treated the same, but not rinsed. The last pair was merely rinsed in water and dried.

Of paramount importance, it was found, is the necessity of rinsing the stock thoroughly after immersion in either phosphating solution. In those test pieces which were not rinsed after phosphating, the pieces rusted much more rapidly than did the ninth and tenth tubes that were just rinsed and dried after the pickling operation. It was found that the more acid the phosphating bath, the more danger of rusting through improper rinsing methods. The "Banox" solution appeared more favorable in this aspect, since it is used in a more neutral range (pH = 3.5 to 4.0).

Lubrication effected by two phosphating methods was studied comparatively at the Gambrinus cold drawing department. The program entailed tests of a number of steel types, including the difficult alloys for high-temperature service. Bales of tubing of each type and same size were divided on a 50-50 basis — each half phosphated by one or the other method. These specially handled bales were then drawn on a bench having a recording meter attached by which the power required for each tube could be observed and recorded. A record was also made of die life and mandrel-plug life per bale. It was found that the average power input per tube drawn did not vary significantly between the differently phosphated tubes; also that any difference in the die and mandrel-plug life due to a possible difference in the two phosphating processes was more than shrouded by other more imposing factors such as variances in the dope coating (dryness), in outside and inside diameter of the tubes, in hardness, and in die and mandrel-plug shapes — all of which



are not finely controllable factors on a production line setup.

However, the comparative consumption of the two compounds was quite well established over a three-month period. During this period, a tank solution of the formerly used phosphating compound and a tank of "Banox" solution were set up side by side and tube bales were split 50-50 during this entire period — half processed in one tank and half processed in the other tank. Consumption was found to be 665 lb. of "Banox" while using 1875 lb. of the other phosphating compound on a total of 6680 tons of tubing (3340 tons of steel in each solution).

It follows then that the costs of compound per ton of steel phosphated are:

$$\text{Original compound: } \frac{1875 \text{ lb.}}{3340 \text{ tons}} @ \$0.205 = \$0.115 \text{ per ton}$$

$$\text{"Banox": } \frac{665 \text{ lb.}}{3340 \text{ tons}} @ \$0.233 = \underline{0.046}$$

$$\text{Saving, per ton of tubing } \$0.069$$

With 37,230 tons of tubing processed at the Gambrinus plant of The Timken Roller Bearing Co. in 1948, the saving in cost of phosphating compound alone amounts to $2,570.

Observation indicated that both phosphating solutions operate for a year or more with constant replenishing without a general cleanup. However, the solution used prior to 1947 requires two steam coils (with installation and maintenance) plus a supply of steam for the entire year. The "Banox" tank simply requires an air line for agitation; since the solution is not heated, there will be no interior scaling of the air lines.

The new compound does an equally good job, is easier to handle, costs 60% less for replacement from consumption, and requires no heating equipment.

Small Tubes —

Train of Improvements Results From Study of Material and Equipment

By Charles T. Flachbarth and Chester S. Pondo
Former Chief Engineer *Metallurgist*
Precision Tube Co.
Philadelphia

THIS is a case history of the application of improved metallurgical engineering methods, improved processes, improved tooling and improved material utilization to achieve economy in production and an improved product in the cold drawing of seamless brass tubing.

It started out to be a routine production job and ended up by reducing manufacturing costs by 36%, introducing a continuous processing saving of $450 a month, led to a new tooling program which paid for itself in four months, reduced scrap losses 40%, and made a better product!

The problem that confronted the Precision Tube Co. of Philadelphia was to make high quality ink tubes for ball-point pens. These tubes must be held to close dimensional tolerances for subsequent assembly. They must lend themselves to cold forming. Above all, they must have a smooth surface to facilitate ink flow in the finished pen.

Ink tubes were originally specified of low leaded brass in the belief this would be best for cold forming. A preliminary study showed, however, that 70-30 cartridge brass would finish with a brighter, less grainy surface and would be less susceptible to fire cracking when annealed in a continuous furnace under a hydrogen atmosphere (which is Precision Tube Co.'s standard practice).

The standard mill length for cartridge brass for redraw purposes is 18 ft. Since the first cold draw was planned as a reduction of 52.1%, it would have been necessary to cut this stock in half to fit our drawbenches. It was found that the supplier could furnish 10-ft. lengths at no extra charge, so the sawing operation was eliminated.

Several carbide drawing dies were alternated for the first draw, one die being used while others were repolished. Some dies needed repolishing sooner than others; those with a short bearing space in the die lasted longest. A bearing space whose length was about 30% of the die diameter proved best for cold drawing cartridge brass.

Some dies chipped out at the relief end. These were noticed to be those in which the bearing space was close to the back of the die, leaving a shallow relief and causing undue stress concentration at the edge of the die bearing region. Boring out this relief to shift the bearing region toward the front of the die eliminated this trouble. This revamped die design proved so successful that all dies in the whole die room were altered accordingly. The increased die life was equivalent to a saving of $200 a month; the work involved in reboring and polishing several hundred dies was paid for within four months in fewer die failures and less repolishing time. Another advantage was fewer interruptions in drawbench operations due to die replacement.

With die life greatly extended and material breakage negligible, it appeared logical to try still greater area reductions. The reduction in the first draw was therefore increased from 52.1% to 62% at 65 ft. per min. without mishap. Lubrication was then the limiting factor. The lubricant in use was a light mineral oil, but an afternoon of testing convinced us that a water-soluble lubricant would permit greater drawing speeds. We adopted a one-to-nine solution of "Rycosol-56", made by the Riley-Whiteman-Walton Co. of Conshohocken, Pa., and were able to increase drawing speed from 65 ft. per min. to 165 ft. per min. The new lubricant had the unexpected advantage of increasing die life still another 50%! In addition, there was a lower

consumption which showed a $150 monthly saving over mineral oil.

Greater reduction and faster drawing led to greater work hardening. This meant that, later on in the processing, the annealing temperature could be dropped. This resulted in fuel economy. At the same time a larger grain size would result from annealing, leading to a capacity for greater reduction on the next pass. Sure enough, we were able to boost the area reduction from 48% to 58% at 165 ft. per min. on the second draw. Proceeding in this manner, we were able to eliminate one drawing operation from the sequence and still achieve the same over-all reduction.

We knew these tubes were made in accordance with sound metallurgical thinking and good tooling practice. They could be duplicated in unlimited quantity. From a manufacturing point of view, this proved to be the best attribute of all. The total number of ball pen ink tubes now produced in this manner runs into astronomical figures. As they say, "laid end to end they would reach from New York to Denver".

Accompanying tables show the production steps and comparative costs.

Cost Comparisons

	Original	Revised
Material: Brass	Same cost per pound	
Cutting scrap	12%	5%
Breakage	19%	2%
Finish rejection	16%	<0.5%
Swage ends loss	22%	5%
Scrap loss reduction		40%
Productive Labor. (Including unloading, cutting, cleaning, drawing and inspecting):	34 operations	18 operations
Reduction in productive labor cost		45%
Indirect Shop Labor: Repolish dies	every 4 hr.	every 22 hr.
Reduction in indirect shop labor		82%
Overhead: Savings in die breakage due to die contour	Save 2 dies per month at $100 each	
Savings due to improved lubricant	$100 per month	
Savings in lubricant cost	$150 per month	
Savings in supervision	20%	
Reduction in overhead		27% of direct labor
Over-All Reduction in manufacturing cost:		36%

Table I — Production Schedules Before and After Revisions

Operation	O.D.	Wall	Reduction	Hardness*	Grain Size	Anneal Temp.	Hardness*	Grain Size	Additional Operations
	Before Annealing					After Annealing			
	Original Production Schedule, Using Low Leaded Brass (66% Copper, 33.5% Zinc)†								
As received	1.000	0.065		65	0.048 mm.				Cut in half, swage end
1. Draw	0.712	0.0435	52.1%	91.5	Note *(a)*	1300° F.	64	0.034 mm.	Cut in half, swage end
2. Draw	0.558	0.029	48.0	91	Note *(a)*	1250	56	0.041	Cut in half, swage end
3. Draw	0.452	0.016	55.2	91	Note *(a)*	1250	61	0.042	Cut in half, swage end
4. Draw	0.333	0.0105	48.2	88.5	Note *(a)*	1200	64	0.048	Cut in half, swage end
5. Draw	0.267	0.0085	47.2	88	Note *(a)*	1150	68	0.030	Swage end
6. Sink	0.215	0.0085	21.1	83	Note *(a)*	1150	65	0.041	Swage end
7. Sink	0.178	0.010	23.0	86	Note *(a)*	1150	61	0.041	Swage end
8. Sink†	0.123	0.010	29.2	79	Note *(a)*				
	Revised Production Schedule, Using Cartridge Brass (70% Copper, 30% Zinc)‡								
As received	1.000	0.065		65	0.072 mm.				
1. Draw	0.695	0.035	62.0%	92.5	Note *(a)*	1300° F.	60	0.076 mm.	Cut in half, swage end
2. Draw	0.538	0.019	58.0	92	Note *(a)*	1250	60	0.079	Cut in half, swage end
3. Draw	0.400	0.012	51.5	90.5	Note *(a)*	1150	70	0.034	Cut in half
4. Draw	0.329	0.0085	45.5	88	Note *(a)*	1000	75.5	0.015	None
5. Sink	0.227	0.009	33.7	83.5	0.019 x 0.013	None			None
6. Sink	0.178	0.0095	19.3	87.5	0.031 x 0.006	1050	71.5	0.019	Swage end
7. Sink‡	0.123	0.010	28.0	86	0.041 x 0.013				

*Rockwell 15T scale.

†Outside of tube bright and smooth; inside of tube has slight undesirable "orange peel" finish. ‡Outside of tube bright and smooth; inside of tube bright and smooth; structure sound; dimensions precisely correct.

Note *(a)* Grain size of severely cold worked brass is indeterminate.

Furnace Management —

Modern Continuous Furnace for Heat Treatment Used as a Gas Carburizer

By Trebor B. Morris
Chief Metallurgist
American Iron & Machine Works Co.
Oklahoma City, Okla.

THE American Iron & Machine Works Co., managed by M. G. McCool, manufactures oil field equipment. The various products, such as tool joints, taper taps, overshot slips, valve assemblies, and miscellaneous parts require controlled atmosphere and carburizing furnaces for their heat treatment. Until our new design of the "straight grip tool joint" was promoted, these were heat treated in box-type furnaces and carburized in cyanide. Since this equipment was not suitable for heat treating the threaded tool joints, a pusher-type, gas fired radiant tube furnace, with an automatic elevator to quench the hot parts in oil, together with a heat exchanger, washer, and draw furnace were installed by the Electric Furnace Co. However, the production of the new tool joint did not fill more than one third the capacity of the new installation. Realizing the expense of idling this equipment, we experimented on using it for carburizing as well. Our products had been carburized in pots for years, but at intervals failure of the parts was excessive. Illustrations of some typical oil field tools that are carburized are shown in Fig. 1, and a description of their uses is as follows:

Overshot slips are used to wicker the outside diameter of broken pipe in the hole, fishing it out.

Taper taps are inserted *into* the pipe, threading it and fishing out.

Valve and seats are used in mud slush pumps, a service which involves wear and impact as the valve opens and closes on the seat.

Mills are used for literally grinding and tearing up any scrap, or wedging out crimped pipe for a tap in order to fish out.

The type of steel, case depth, and specified hardness are shown for these products:

Product	Type of Steel	Case Depth, Inch	Rockwell Hardness
Overshot slips	1020, 4620	0.020 to 0.030	C-58 to 61
Taper taps	1035, 4620	0.020 to 0.030	58 to 61
Milling shoes	4620	0.035 to 0.045	58 to 61
Valves	4620, 4815	0.035 to 0.045	55 to 58
Seats	8650, 3140	None	42 to 48

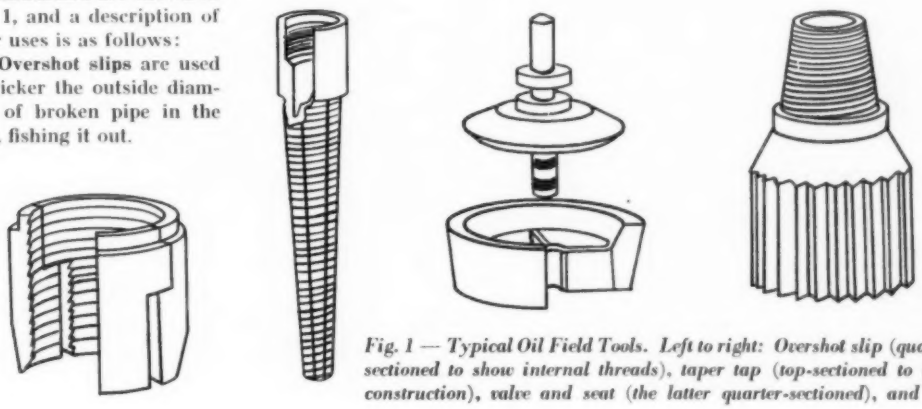


Fig. 1 — Typical Oil Field Tools. Left to right: Overshot slip (quarter-sectioned to show internal threads), taper tap (top-sectioned to show construction), valve and seat (the latter quarter-sectioned), and mill

Results of Pot Carburizing — The process treatment was preheating to 1200° F., then transferring to the cyanide pot and holding at 1650° F. until the specified case depth had formed, and quenching the alloy steel in oil. The 1020 steel was quenched directly in water from the pot. The alloy steel was reheated to 1500° F. and quenched in oil. Due to the high carbon concentration on surfaces with case depths of 0.025 in. and deeper, segregation of free carbides formed near the surface both as fairly large crystals throughout the matrix and as a network of very fine particles outlining the grains of austenite.

Chemical analysis for carbon of turnings from cyanided A.I.S.I. 4620 bars (1 in. diameter) at different case depths verified the microscopic observations:

Depth Below Surface	Case Depths		
	0.015 In.	0.025 In.	0.035 In.
0.005 in.	0.78%	1.16%	1.34%
0.010	0.52	0.98	1.12
0.015	0.32	0.61	0.86
0.020	0.21	0.48	0.67
0.025		0.30	0.54
0.030		0.22	0.44

With the high concentration of surface carbon in the deeper cases (0.025 and 0.035 in.), we experienced a considerable number of failures. The threads (splines) on the overshot slips and taps would peel off. The case on the valves would flake out, caused by direct impact loading on the seat. Shallow case depths of 0.010 to 0.015 in. resulted in fast wear, down to the soft core. It was found that by controlling the surface carbon concentration (thus the carbides), the life of the products was lengthened. This led to the experiments of carburizing in the Electric Furnace Co.'s gas fired hardening furnace.

Our equipment consisted of the following:

Radiant tube, pusher-type, gas fired furnace. (21 tubes, 5 ft. 3 in. long; one U-tube at discharge.)

Catalytic endothermic generator, output 2000 cu.ft. per hr.

1800-gal. oil quench tank (Houghton's soluble quench oil).

Oil conditioner with coolant and heat exchanger; filters.

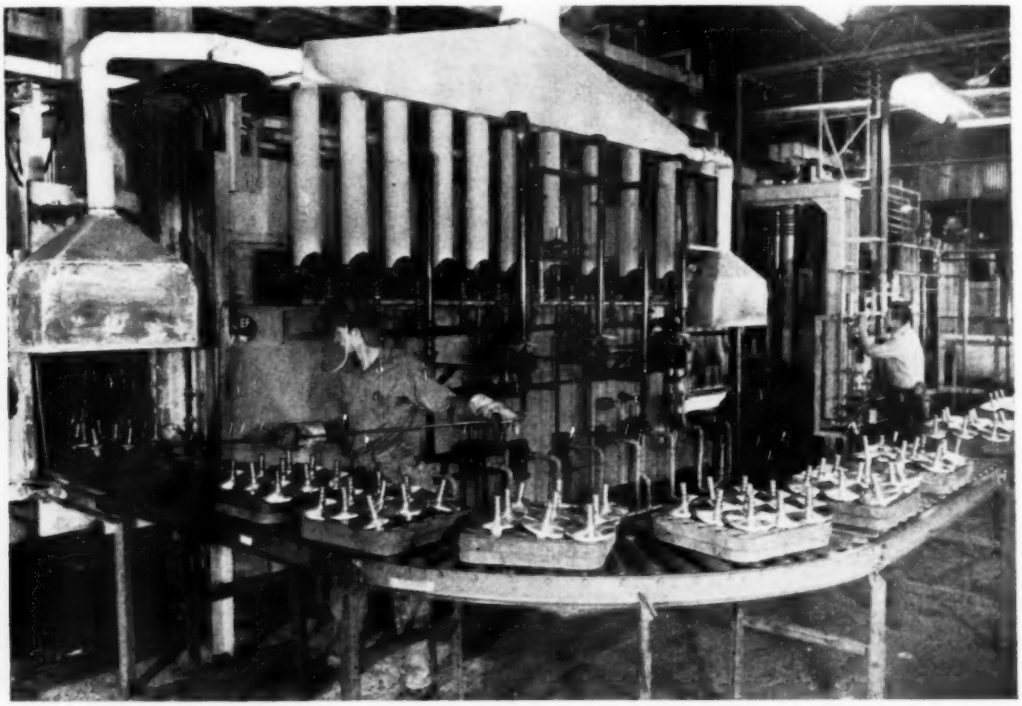
Eclipse boiler for heating oil and water rinse.

Two-stage caustic soda and hot water rinse tank.

Pusher-type draw furnace; 300 to 1200° F.

Cold water spray tank at discharge of draw.

Fig. 2 — Valves of 4620 Steel Entering Charging Vestibule of Controlled Atmosphere Furnace for Carburizing



For hardening, this furnace operates in a perfectly normal manner. The material is carried on an 18x18-in. tray, which is charged into an air-locked vestibule. At timed intervals the single row of trays is pushed into the reaction chamber on a three-rail skid track. The reaction chamber is reasonably airtight, due to air-locked charge and discharge vestibules. The discharge vestibule hangs below the oil level, and the trays are lowered by elevator into a highly agitated oil at 120 to 140° F. The trays are withdrawn through the open-top part of the quench tank, and continue through a rinse tank which is divided into a hot caustic soda rinse and a hot water rinse. The trays continue on into the draw furnace. The cold water spray at the discharge end of the draw furnace is mainly for materials receiving a high draw temperature.

Table I — Gas Analyses

Constituent	Natural Gas			RX Gas
	Low B.t.u.	High B.t.u.	1050 B.t.u.	
CH_4 (methane)	72.0	76.0	75.0	0.30
C_2H_4 (ethane)	14.8	12.5	14.2	0.00
C_3H_8 (propane)	0.5	1.5	1.0	0.00
C_4H_{10} (butane)	0.2	0.4	0.5	0.00
CO_2	0.8	0.4	0.4	0.10
O_2	7.5	6.0	7.0	0.00
H_2	0.2	0.1	0.0	37.80
H_2O	0.1	0.1	0.1	0.00
N_2	3.8	3.0	2.2	41.70
CO	0.2	0.0	0.0	20.10

Routing of the products, each with a certain type of treatment, is arranged so that minimum time is lost from purging the furnace of the carburizing atmosphere and building up the proper atmosphere for hardening the medium carbon steels. The threaded tool joints require approximately 72 hr. per week with 250 to 300 lb. per tray. The seats follow at the same temperature, but their draw temperature is lowered from the 1050 to 1100° F. used for tool joints to 850 to 900° F.

Late Friday, scrap is loaded into the furnace for the week end, with the furnace held at 1400° F. Early Monday morning, the temperature is raised to 1700° F. and natural gas is added direct to the atmosphere chamber through two ½-in. openings located 6 ft. apart at the center of the furnace. The valves (for a specified 0.035 to 0.045-in. case) are loaded, 100 to 125 lb. per tray, and the push timed at 1-hr. intervals. The large size slips and part of the milling shoes with 0.025 to 0.035-in. case can be carburized with the valves, due to their thick wall areas.

Gas Analysis — The natural gas furnished Oklahoma City comes from two fields, and the chemical composition varies within the limits shown in Table I. Interpolation between these limits gives a gas with the average heat value of 1050 B.t.u., and the theoretical analysis of the RX gas is computed in the last column.

When heat treating the medium carbon steel without carburization, the air-gas ratio is maintained at approximately 2.4 air to 1 gas. This ratio seems to maintain the dew point reading between zero and 10° F. The average RX gas is retained slightly on the carburizing side and input is approximately 625 cu.ft. per hr. The resultant product's surface has a clean, gray-brown color.

When the furnace is carburizing, the air-gas ratio is slightly reduced in the generator for a richer mixture, but the gas flow of 625 cu.ft. per hr. is not increased. Approximately 10% of natural gas is added to the reaction chamber. The temperature is set at 1700° F. and reduced to 1600° F. at the discharge end for quenching. The average carbon concentrations obtained from the 7½ and 11-hr. treatments in the reaction chamber, giving 0.030 and 0.040-in. case, respectively, are:

Depth Below Surface	Case Depths	
	0.030 In.	0.040 In.
0.005 in.	0.61%	0.78%
0.010	0.56	0.66
0.015	0.48	0.54
0.025	0.38	0.48
0.035	0.25	0.41
0.045		0.30

Some difficulty has been met in retaining the carbon concentration up to and over 0.70%, mainly in the 0.025 to 0.035-in. cases, but we believe this will be solved by a better distribution of the natural gas in the reaction chamber and by adjusting the richness of RX gas. However, we have not experienced any difficulty in retaining uniform case depths with constant time cycles and tray loads. Although the concentration at the surface is not quite as we would prefer, the hardness is within the specified range after a 300° F. draw.

Summary — Inasmuch as gas carburizing is not a new process by any means, I was quite surprised that we were apparently the first to utilize the extra capacity of a modern hardening furnace for carburizing. The few points that may be summarized as being economical to our company are:

1. Greatly improved products. The valve and seat are now known as the best on the market.
2. Improved production schedules.
3. Decrease in cost of carburizing.
4. Utilizing the extra furnace capacity until increasing tool joint production gradually requires the full capacity of the hardening furnace.

Annealing for Machinability —

Isothermal Treatment of X4340 Increases Furnace Capacity 56%

By Kenneth Midlam
Plant Metallurgist
American Locomotive Co., Railway Steel-Spring Div.
Latrobe, Pa.

DURING the trying days of the recent war it became necessary to change the grade of steel used for certain ordnance gear rings from W.D. 4640 to W.D. X4340, so as to make better use of the triple-alloy scrap available. Difficulties were encountered in machining the X4340; "hard spots" necessitated a general reduction in machining feeds and speeds.

At the Latrobe plant, Railway Steel-Spring Div. of the American Locomotive Co., several possibilities were considered: *(a)* request permission to return to 4640, *(b)* request a modification of X4340 permitting the use of triple-alloy scrap in the open-hearth with no minimum chromium content specified, *(c)* modify the heat treatment to improve machinability while still meeting the required specifications for mechanical properties. It was decided that the best solution would be to develop a heat treatment which would improve the machinability, since returning to 4640 might prove to be just a temporary measure. Also, any heat treatment finally evolved would be applicable to a modified (that is, lower chromium) X4340, as well as to X4340. Therefore, studies on heat treating cycles were instituted immediately in the metallurgical laboratory.

Both the original and revised specifications for these gear rings called for a Brinell hardness of 170 to 235. Figure 1*(a)* shows the distribution curve of Brinell hardness on 412 rings produced from 4640 steel, normalized and then annealed with furnace cooling to 800° F. The same procedure was at first followed on the X4340 steel, except that the furnace cooling was continued to 600° F. Although the hardness was very similar to that obtained on 4640, machinability was poor. Shop records show that the total heat treating cycle on 4640 took approximately 23 hr. per furnace charge and that the additional cooling to 600° F. on the X4340 increased the time to 25 hr. per furnace charge. Microstructures are shown in Fig. 2*(a)* and *(b)*.

To increase the amount of spheroidization, the annealing cycle was changed to permit more transformation at the higher subcritical temperatures; the cooling was controlled at 30° F. per hr. from 1350 to 1000° F. Figure 2*(c)* shows the microstructure obtained, and Fig. 1*(b)* the Brinell hardness distribution among 218 rings. Under this revised heat treating procedure, the furnace time per charge was reduced to 20 hr. on the X4340 steel. This is equivalent to a 20% increase in production capacity.

Additional laboratory investigations indicated that some form of isothermal transformation might further reduce the time involved in the heat treating cycle, and the following procedure was finally evolved: Heat to 1400° F., cool rapidly in the furnace to 1175° F., hold 4 to 6 hr., depending on heat analysis, and air cool. Figure 1*(c)* gives the Brinell hardness distribution curve obtained on 468 rings processed in this manner, and Fig. 2*(d)* shows the microstructure, a mixture of fine carbide spheroids, fine lamellar pearlite, and "blocky" ferrite, which seems to be an ideal structure for machinability.

As can be seen from Fig. 1*(c)*, there are fewer of the rings on the high side of the specification, although the range of Brinell readings is greater; therefore, the probability of "hard spots" is reduced and more consistent machinability properties are realized.

This modified isothermal heat treating cycle further reduced the heat treating time to about 11 hr. per furnace charge, an increase of 45% in capacity over the controlled furnace cooling practice, or a total over-all increase from the original process amounting to 56%.

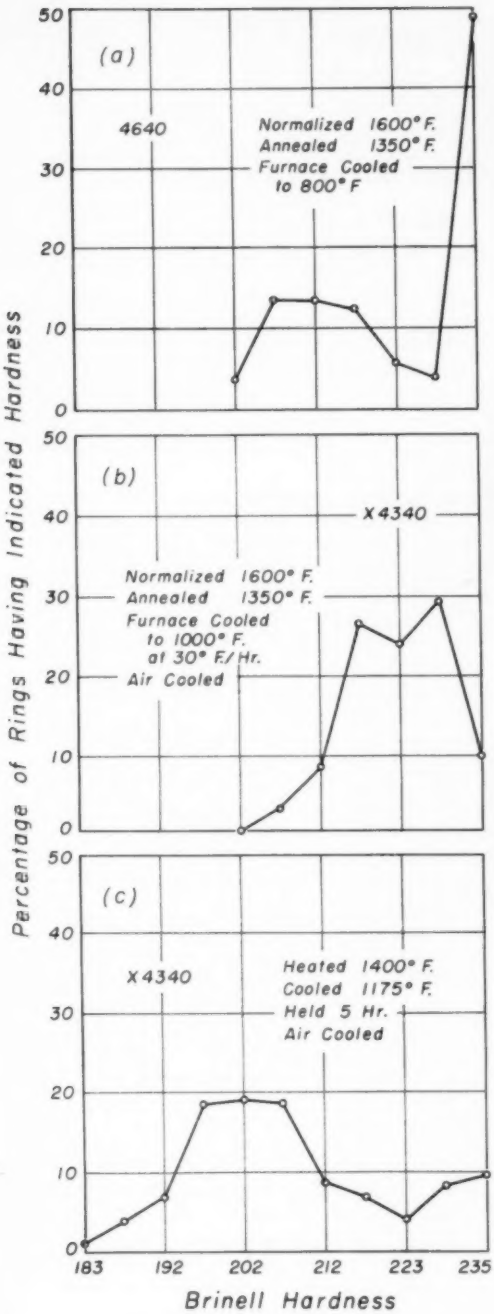
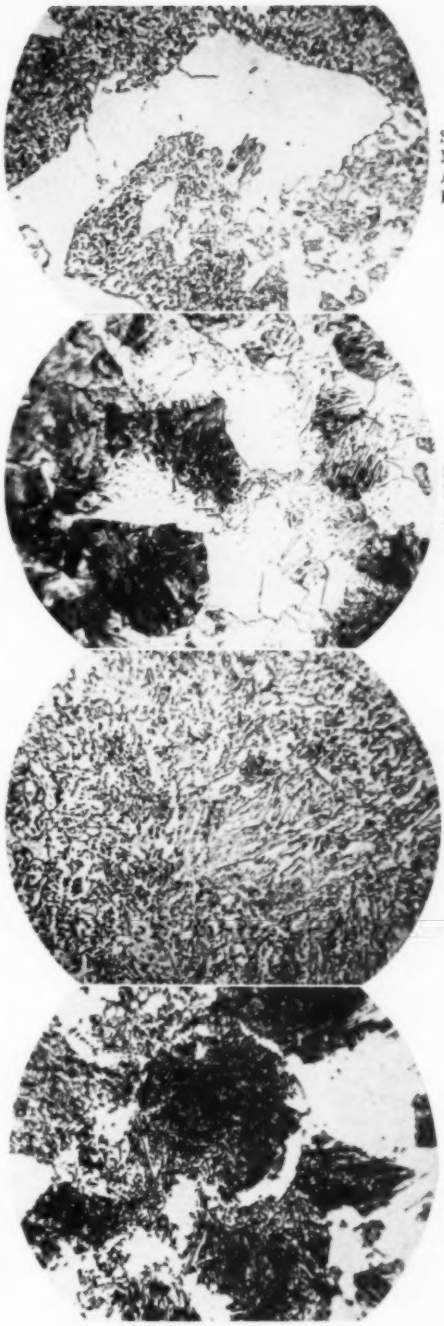


Fig. 1—Hardness Distributions After Various Annealing Treatments



(a) Steel 4640 Norm. 1600° F. Anneal 1350° F. Furnace cool to 800° F.

(b) Steel X4340 Norm. 1600° F. Anneal 1350° F. Furnace cool to 600° F.

(c) Steel X4340 Norm. 1600° F. Anneal 1350° F. Furnace cool to 1000° F. at 30°/hr. Air cool

(d) Steel X4340 Heat 1400° F. Cool 1175° F. Hold 5 hr. Air cool

Fig. 2—Microstructures After Various Annealing Treatments

Flame Hardening —

Selective Flame Hardening Machine for Tractor Gears Results in Economy and a Better Product

By A. E. Anderson and R. H. Lundquist
In Charge of Heat Treat Dept. *Supervisor, Metallurgical Dept.*
Minneapolis-Moline Co.
Minneapolis

UNTIL late 1944 all final-drive tractor "bull" gears were heat treated by conventional quench-and-temper methods at Minneapolis-Moline Co. Weldless rolled rings of 1040 steel were finish-machined and then heated in a Leeds & Northrup "hump-type" furnace for hardening. The heated rings were transferred manually from the furnace to a water quench tank, where they were placed around a cast-iron "spider" or hub. Plates were placed on both sides of the gear so that only the teeth were exposed to the full effect of the quench. The assembly was then immersed in the water quench to harden the teeth and to shrink the ring on the spider. The assembly, consisting of the hardened steel ring and cast-iron spider or hub, was then tempered at 725° F., which resulted in a tooth hardness of 38 to 44 Rockwell C.

It was well known by our people that the gears processed in this way left much to be desired. Some of the major disadvantages were:

1. Service life was not satisfactory. The bull gears are driven by carburized and hardened pinions, and under extreme service requirements, failures of the gears occurred as a result of excessive wear and pitting.
2. The treatment involved considerable labor and the cost was high.
3. Unless the quenching temperature of the rings was changed to meet various hardenabilities of different heats of steel, the resulting shrink fit of the gear on the spider was not entirely satisfactory.
4. Production with available equipment was only 82 gears per 24 hr.

It was realized several years previous to 1944 that it would be advantageous to process these bull gears differently. Consequently an extensive program of research and testing was conducted in order to determine a new procedure. Test tractors containing experimental gears were operated under the most severe service conditions for many months. By early 1944 it had been determined that bull gears made of C1038 fine-grained steel, selectively hardened by a natural gas flame method, gave field test results far superior to those for gears hardened by the old method. It was also determined that, in addition to better quality, the flame method would result in lower cost.

As a result of these investigations, the flame hardening machine shown in the accompanying photographs was designed by our engineering department and built in our shops. The machine has two work stations so that gears may be unloaded and loaded at one station while another gear is being rotated, heated, and quenched at the other station.

Figure 1 shows the gas burner manifold about to drop over the ring gear which has been loaded into the right-hand station with the spider on top of it. Figure 2 shows the gas burners heating the teeth of the ring gear. The ring has not yet been heated sufficiently to provide for enough expansion to allow the spider to drop down into the gear. The assembly rotates at about 25 r.p.m. to provide uniformity of heating.

Figure 3 shows a ring and spider in the left-hand station which has been heated long enough to make the ring expand to allow the spider to drop into place. Figure 4 shows a ring and spider in the left-hand station heated to quenching temperature and about to be immersed in the water quench. The gas burner manifold is being raised and will soon be in the position shown in Fig. 1.

Figure 1 shows the quenching operation in the left-hand station. The assembly has been

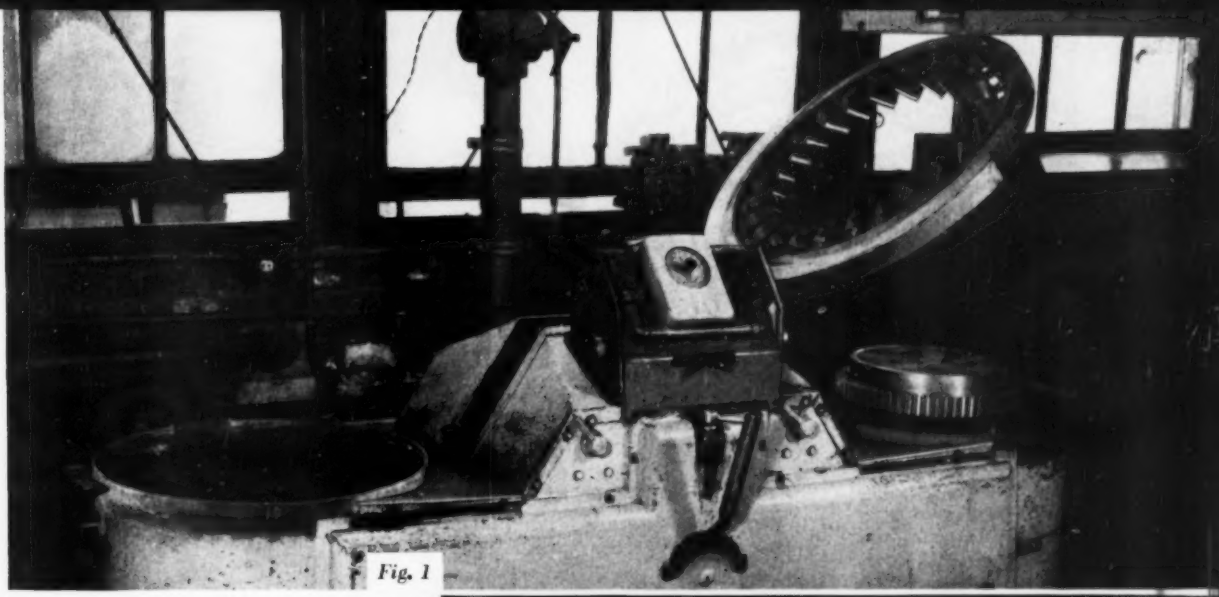
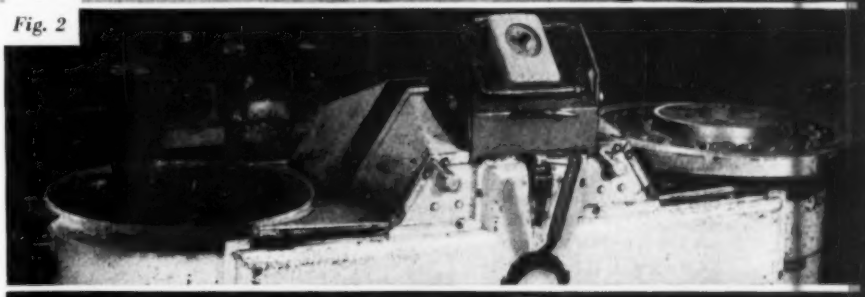


Fig. 1

Fig. 2



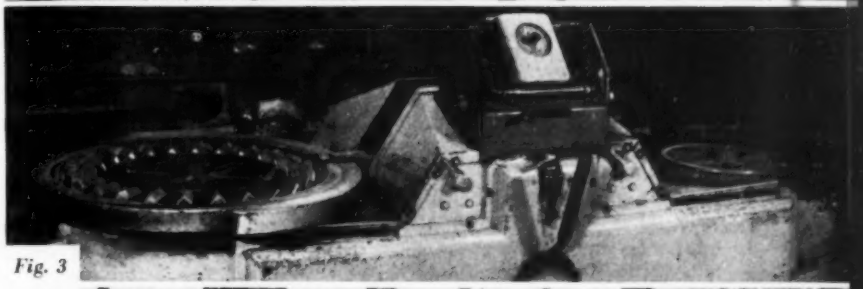
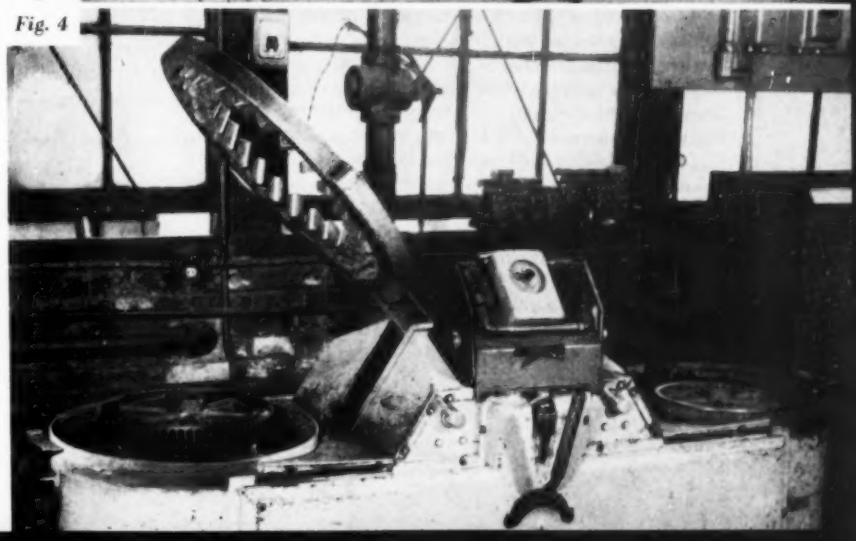


Fig. 3

Fig. 4



immersed in the water quench, which contains a submerged spray ring to provide ample agitation to "wipe off" steam pockets and thereby attain a rapid quench and good mechanical properties in the roots of the teeth. The gear is now ready to be tempered in a furnace at 425° F. for 3 hr.

Figure 5 shows the ring, spider, and assembly of a typical gear which has been hardened by this method. The ring gear pictured is 15.532 in. o.d. with a 2⅜-in. tooth face. This gear is heat treated and shrunk on the spider by this flame hardening method at the rate of one every 4½ min.

The C1038 rings are annealed before machining, as follows:

Austenitize at 1650° F. for 5 hr.
Force air cool to 900° F. in 1 hr.
Hold at 1150° F. for 5 hr.
Air cool to room temperature.

The resulting machinability is good, and tooth contour and finish are accurate enough so that no shaving or further

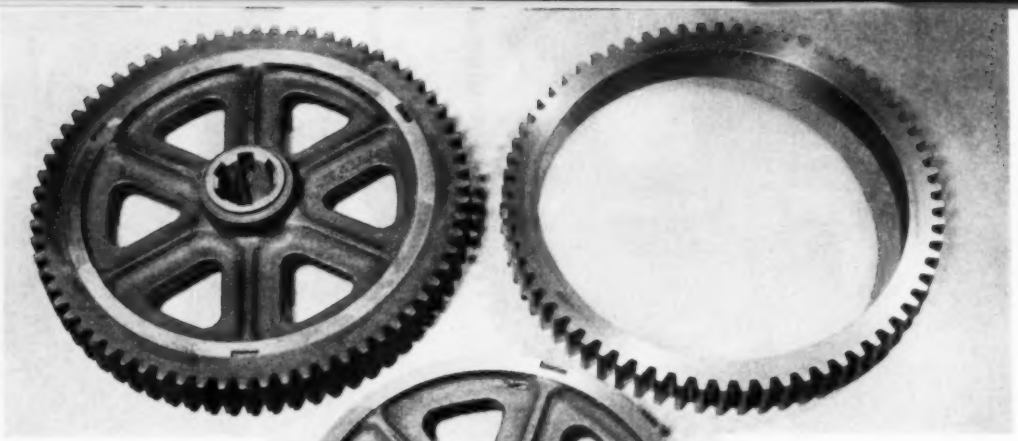


Fig. 5 — Ring, Spider and Assembly of a Typical Gear Treated by Selective Flame Hardening. Ring gear is 15.532 in. o.d. with 2 3/8-in. tooth face

machining is required.

A hardness survey which is considered typical of gears hardened by this method is shown in Fig. 6. It can be seen that fillets at the roots of the tooth are hardened to around 52 Rockwell C to resist fatigue failure at these points. The wearing face of the tooth is maintained at 54 to 55 Rockwell C for good wear resistance.

The fuel used for this hardening operation is natural gas of 1000 B.t.u. per cu.ft. heating value. It is mixed with air at a 10 to 1 ratio and supplied under pressure to the burner manifold. The burners are ceramic lined with heat resisting steel jackets.

The flame hardening machine described has proved to be extremely versatile. Cylinder teeth for grain harvesters have been hardened at the rate of 1350 per hour by using special slotted holding fixtures instead of the gear spiders. Carburized C1018 helical gears, 12 in. diameter, have been hardened with less than 0.003 in. distortion.

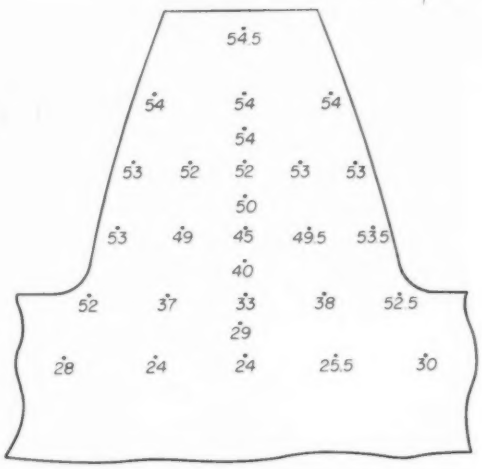


Fig. 6 — Typical Hardness Survey of Gear Tooth

Summary — The advantages of the selective flame hardening method described are as follows:

1. The gears produced are far superior from a service standpoint because distortion is minimized, the hardness at the wearing surfaces is much higher, and the strength at the root of the teeth is much higher.

2. Our requirements for ring gears can be produced by the new method with less than one third the capital investment for equipment, compared with the old method.

3. Floor space required is less than one third that required by the old method.

4. The flame hardening machine is much more versatile in that many parts other than ring gears can be selectively hardened.

5. Flame hardening of ring gears can be paced to machine shop production, resulting in smoother flow of material.

In our opinion this method of selectively hardening large, heavily loaded gears warrants more consideration than it has been given in the past. It requires considerably less investment than other equipment which does a similar job, and is capable of producing hardened gears which have proven themselves by years of field service.

Electroplating With Solder —

Electroplating Lead-Tin Alloy on Small Parts Facilitates Subsequent Soldering

By L. H. Seabright
Metallurgical Engineer
Kellogg Switchboard & Supply Co.
Chicago

MANY soldering operations in the electrical industry require the use of a noncorrosive flux in order to avoid damage to certain components. In order to perform these soldering operations, it is frequently necessary to precoat certain parts with a solder alloy. This is usually done by electroplating with pure tin or by dipping the parts in flux, then in molten solder, and finally centrifuging to remove the excess solder. The principal difficulty with electroplated coatings of pure tin is that they will oxidize within a few weeks, making soldering difficult or impossible. Hot dipped solder coatings are usually porous and vary in thickness from 0.0003 to 0.010 in.; because of the porosity, the parts are likely to corrode or discolor in stock, making soldering very difficult. It was while considering the disadvantages of these two processes that I thought of electroplating a solder alloy.

Investigation disclosed that a process was available for plating lead-tin alloys from a fluoborate solution. This solution had been commonly used for plating alloys of low tin content, but indications were that it could be used just as easily for electroplating the lead-tin solder alloys. A low-melting alloy with 60% tin, 40% lead was selected in order to expedite production and minimize overheating of the work. The lead-tin alloy plating solution was prepared from fluoborate concentrates available from the General Chemical Co. The following bath composition was found suitable for plating 60% tin, 40% lead:

Total Tin	60.0 g. per l.	8.1 oz. per gal.
Stannous Tin	55.0	7.4
Lead	25.0	3.35
Free Fluoboric Acid	80.00	10.8
Free Boric Acid	25.00	3.4
Glue	5.00	0.67

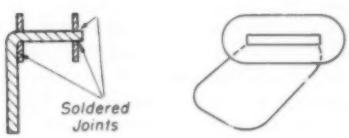
The bath was operated between 60 and 100° F., at a current density of 30 to 50 amp. per sq.ft., with mild agitation obtained by barrel plating or by moving the cathode rod. Anodes were 60% tin, 40% lead, and their surface area was about twice that of the cathodes. This operation was developed in cooperation with Mr. J. Trezek, foreman of plating.

Based on the analysis of the lead and tin concentrates, and the suggested composition of the bath, the following amounts of ingredients were required for preparing a 100-gal. bath:

Tin Fluoborate Concentrate	260 lb.	19.6 gal.
Lead Fluoborate Concentrate	75.5	4.9
Water	—	65.5
Additions		
Fluoboric Acid (42%)	121.0	10.0
Boric Acid	9.3	—
Glue	4.2	—

After some preliminary work, the finish on several coil terminals was changed from hot dip solder coating to lead-tin alloy plating. During a six-month trial period, it was found that rejections from defective soldering had dropped from an average of 10% to zero. All hot dip solder work was then abandoned in favor of lead-tin alloy plating.

One example of the application of this method is a small receiver-coil spool assembly, shown full size below. Formerly, the bottom spool head for



this part was spot welded and the top was soldered to the core. The core is now being plated with 0.001 in. of lead-tin alloy, and a series of these are assembled in a fixture with the nickel silver spool heads. A noncorrosive solder flux is applied to the parts and a tray of the assembled parts is run through a brazing furnace at 675° F. After passing through the furnace, the fixture and parts are rinsed promptly. No subsequent plating is necessary, as the lead-tin alloy coating gives sufficient protection.

This furnace soldering process requires about 30 sec. handling time per part, in comparison with about 50 sec. for the previous method of assembly. The total savings per 1000 pieces is $12.10, or $290.00 per year for a production of 24,000 pieces.

The average rate for production plating of small parts to be soldered varies from 5000 to 10,000 per hr., while the rate for hot dip solder coating was about half this fast. The change has made possible a total yearly saving of $1700 at the Kellogg plant. Following is a breakdown of savings realized for a small terminal, of which we produce two million per year.

	Hot Tinning	Electro-plating
Production per hour	3,000	10,000
Hours per 1000 pieces	0.33	0.10
Labor & burden rate per hr.	$2.52	$3.04
Labor & burden cost	$0.84	$0.30
Savings per 1000 pieces	$ 0.54	
Savings per year	$1,080.00	

Projection Welding —

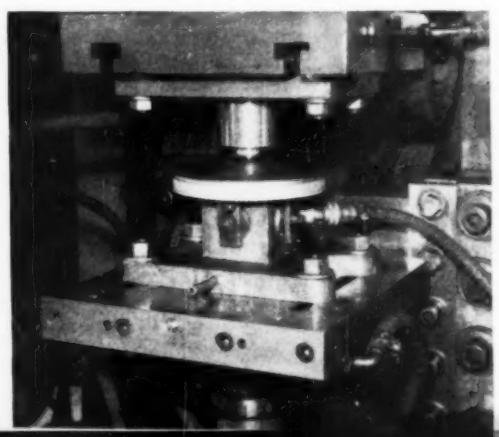
Joining Cost Decreased 80% in Manufacture of Small Pressure Vessels

By R. K. Waldvogel
Welding Engineer
The Johnson Mfg. Co.
Urbana, Ohio

RECENTLY The Johnson Manufacturing Co. started to fabricate small air-pressure vessels of low-alloy high-strength steel 0.067 in. thick. One of the most popular sizes is 8 in. in diameter and 26 in. long. These containers have several openings on the body and heads of the tank which are used for connection to air lines ranging in nominal pipe sizes from ¼ to 1¼ in. These threaded connections, called bushings, were first attached to the tank by gas braze welding. Manual arc welding would have been much faster and cheaper for this product, but no manual arc welding equipment was available in this plant.

Accordingly, to decrease the cost of joining, the possibility of projection welding these bushings was explored. Projection welding is a specialized form of resistance spot welding in which the welding current is localized at several raised projections on the material to be welded. A projection welder was purchased, equipped with the latest type synchronous precision electronic-control panel to permit close control of welding. The accompanying illustration shows the machine welding a bushing to a pressure-vessel head.

Production was increased 500% by the introduction of projection welding, and the manufacturing costs (including labor, overhead, acetylene, oxygen and electric power) were decreased from $0.081 to $0.016 per piece for the ⅜-in. bushings. Since 135,624 bushings of the ⅜-in. size were welded by the new method during the year 1948, the annual saving was $8815 on this one size alone.



Brazed Assembly —

Change of Machined Casting Into Brazed Assembly Saves 75% of Cost

By Lawrence Jacobsmeyer
Executive Vice-President
Salkover Metal Processing of Illinois, Inc.
Chicago

CONTROLLED atmosphere copper brazing is one of the newer metal joining processes which offer important opportunities for cost reduction and frequently for quality improvement.

Generally speaking, copper brazing reduces costs materially where it is applicable. The chief reason for such economy is the fact that the process enables the designing engineer to use stampings and screw machine components rather than castings, forgings or bar stock. It is generally admitted that the stamping press and the automatic screw machine are the economical performers in modern metal manufacturing, and that (in brief) is the secret of copper brazing's "economy in production".

The following letter was signed by A. E. Lundahl, production manager of Miller Wrapping & Sealing Machine Co. of Chicago. It verifies the above statements for even the simple assembly shown in the accompanying illustration. Previously made from a casting, the part is now made from two stampings and a screw machine component and is decidedly cheaper than formerly.

As the complexity of copper brazed assemblies increases, cost savings also increase. Maximum cost advantage is obtained with assemblies which are relatively intricate and relatively light.

Here is the letter from Mr. Lundahl:

"You will be interested, I feel sure, in hearing of the success we encountered in reducing the cost of a cam actuator part through your copper brazing methods.

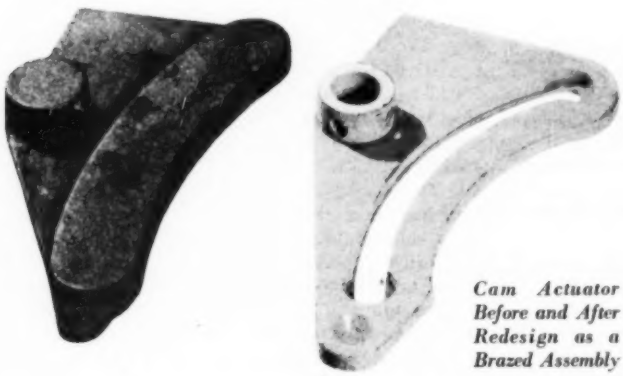
"The part in question was a single gray iron casting machined to close tolerances. Operations consisted of machining the front and back of each casting, drilling and counterboring two holes, drilling and reaming one hole, drilling and tapping one hole, and end milling a long curved slot.

"The new method consisted of dividing the casting into three component parts which could easily be made on the punch press and screw machine and then copper brazing the three into one unit. Here are the cost figures for each method:

	Old Method	New Method
Labor	$ 3.60	$ 0.75
Material	0.35	0.11
Assembly	—	0.08
Brazing	—	0.12
Total	$ 3.95	$ 1.06
Cost of tools	$175.00	$89.00

"If all the tools were charged off to our initial run of 100 pieces (which actually of course they are not) the cost of the old method is $5.70 each and the new $1.95 each. As time goes on, the new method will show even greater savings.

"Samples are being mailed to you for your inspection." (See cut.)



Cam Actuator Before and After Redesign as a Brazed Assembly

Graphitic Toolsteel

Substituted for 18-4-1 High Speed Steel in the Manufacture of Arbors

By Edgar C. Wallace
Metallurgist
Barber-Colman Co.
Rockford, Ill.

UNTIL five months ago, the lathe, sharpening, and grinding arbors of the Small Tool Division of this plant were manufactured from 18-4-1 high speed steel. It had always been deemed necessary to use this material because the arbors support high speed steel tools during the various stages of their manufacture. The constant on-and-off period of the tool on the arbor is a distinct wear problem and until recently no material except hardened high speed steel worked satisfactorily. This was in spite of the fact that the usual advantage of high speed steel was not being realized, namely, its hardness at high temperature, or "red hardness".

The first samples of graphitic steel were tried out in March of this year on one of the more exacting jobs, an arbor to hold a gear cutting hob during the grinding operation. It was estimated that 500 hobs per arbor could be fitted on and off before the wear became appreciable enough so that the arbor had to be chromium plated and reground to size. This was considered equivalent to the regular high speed steel arbors and consequently we have now converted to graphitic steel for more than 95% of our arbor manufacture.

The cost of the material is the only significant cost involved in the substitution. However, the heat treatment of the graphitic tool steel requires less time, an important point when a special arbor is required on a rush order, and it also machines quite readily. On the other hand, the final grinding of the arbor surface requires special wheels and a careful technique so as not to lower the hardness unduly. So far, no difficulties of this nature have occurred.

The heat treatment of these graphitic steels is quite simple. However, close attention must be paid to austenitizing temperatures recommended for each size to obtain the correct carbide solution. The subsequent tempering is also important and depends on the article and its type of service. For arbors that have notches and are used severely, a tempering temperature of 375° F. has worked out quite satisfactorily. Straight arbors with no notch effects work satisfactorily after being tempered between 200 and 250° F.

Heat treatment schedules are as follows:

Quenching Temperatures	
Up to 1 in. round	1475° F.
1 to 2 in. round	1500° F.
2 to 4 in. round	1525° F.
4 in. and larger	1550° F.

Hardness and Toughness After Tempering		
As quenched	64+ R_c	—
Tempered at 300° F.	63 to 64	20 ft-lb. Izod
Tempered at 400° F.	63	22
Tempered at 500° F.	61	24

In almost four months, 1416 lb. of graphitic steel has been used in arbors. Purchased as "Graph-Mo" (Timken) on a toolsteel basis, or more economically as 91140 on an alloy steel pricing, the steel has cost from $0.378 to $0.48 per lb. in the various sizes. The total material cost has been $571.11.

If 18-4-1 high speed steel had been used, 1603.61 lb. would have been required (high speed steel is a denser material), and at $0.935 to $0.96 per lb., the total cost for steel would have been $1511.24.

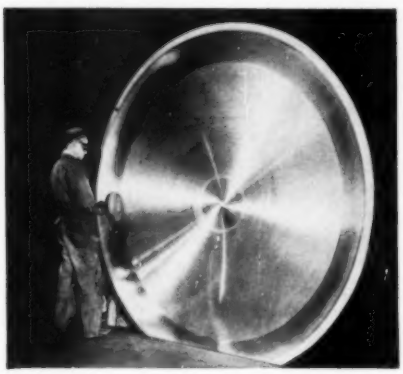
The saving to date (August 20, 1949) therefore has been $940.13. Projected to an annual basis, this would indicate a yearly saving of about $3075 in our plant.

Acknowledgment is given to Messrs. C. H. Carlson and J. E. Rice of the Small Tool Division of this company for their interest in fostering the substitution of this material.

STAINLESS lets you spin 'em BIG!

This large stainless steel tank end being spun to the desired radius is made up of standard width sheets of "18-8" welded together and the welds ground smooth.

(Below) Another large stainless steel tank end, already spun to shape, shown here being polished.



HERE is austenitic chromium-nickel stainless steel, Type 305, being spun into a huge tank end. Another, of Type 302 . . . spun to shape and receiving a polish . . . is pictured at the left.

These large units attest to the adaptability of austenitic stainless steels to this method of fabrication.

Types 302, 304, and especially Type 305, lend themselves well to modern spinning operations according to the producers of these tank ends, Milwaukee Metal Spinning Company (Spincraft) of Milwaukee 8, Wisc. On a production basis, this company spins heads and ends for milk storage tanks ranging from 36 to 102 inches in diameter.

This is only one of many applications in which advantage may be taken of the various useful properties of chromium-nickel stainless steels.

You can trim bulk and deadweight by specifying correct types of stainless. They are strong yet tough, moreover, they resist wear and abrasion.

You get long service life because these alloys are resistant to attack by nearly all oxidizing acid conditions. They assure long, trouble-free performance of equipment, and hygienic cleanliness as well as economy in food, drug, chemical and other process industries.

Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. A list of sources of supply will be furnished on request.

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Don't Forget... Jot down—"INCO Booth, No. 302"—in your memo book of companies to visit at the **NATIONAL METAL EXPOSITION**, at the Public Auditorium in Cleveland, Ohio, October 17th to 21st. Convenient facilities for discussing your problems with our metallurgists and foundry specialists will be made available.

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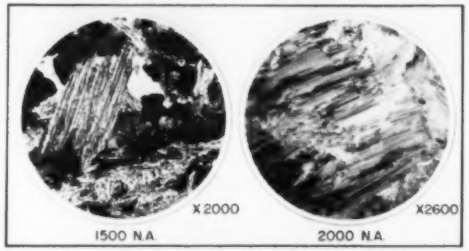
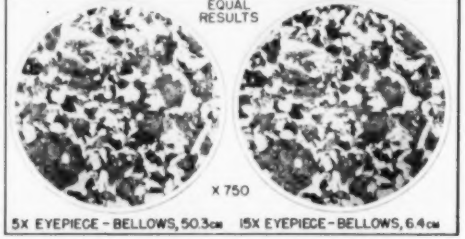
Metallographic Technique for Steel: Photomicrography (cont.)

MAGNIFICATION IN EXCESS OF 1000N.A



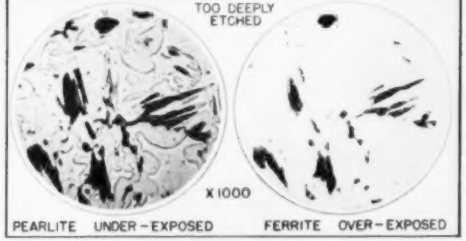
1500 N.A. 2000 N.A.

EYEPIECES & BELLOWS EXTENSION



5X EYEPIECE - BELLOWS, 50.3cm 15X EYEPIECE - BELLOWS, 6.4cm

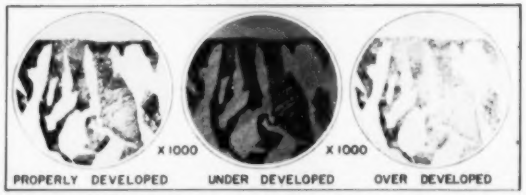
CONTRAST IN EXCESS OF FILM LATITUDE



PEARLITE UNDER-EXPOSED FERRITE OVER-EXPOSED

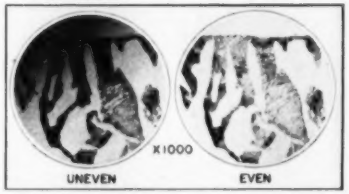
PRINTS FROM PROPERLY & POORLY EXPOSED & DEVELOPED NEGATIVES

PROPERLY EXPOSED UNDER EXPOSED OVER EXPOSED



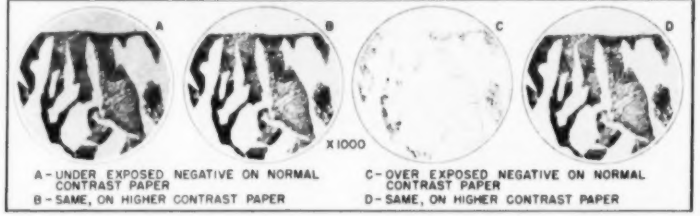
PROPERLY DEVELOPED UNDER DEVELOPED OVER DEVELOPED

ADJUSTMENT OF ILLUMINATION

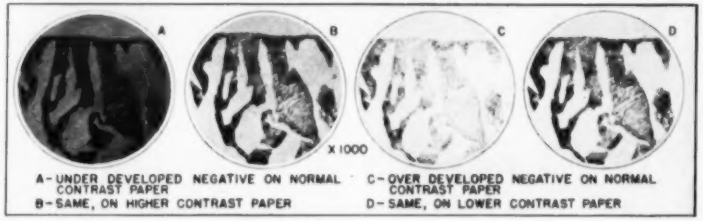


UNEVEN EVEN

USE OF PAPERS OF DIFFERENT CONTRAST TO COMPENSATE FOR ERRORS IN EXPOSURE & DEVELOPMENT



A - UNDER EXPOSED NEGATIVE ON NORMAL CONTRAST PAPER
B - SAME, ON HIGHER CONTRAST PAPER
C - OVER EXPOSED NEGATIVE ON NORMAL CONTRAST PAPER
D - SAME, ON HIGHER CONTRAST PAPER

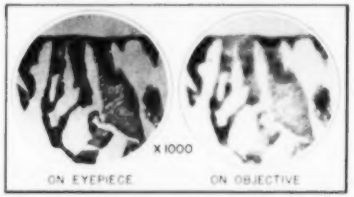


A - UNDER DEVELOPED NEGATIVE ON NORMAL CONTRAST PAPER
B - SAME, ON HIGHER CONTRAST PAPER
C - OVER DEVELOPED NEGATIVE ON NORMAL CONTRAST PAPER
D - SAME, ON LOWER CONTRAST PAPER

EFFECT OF DUST PARTICLES

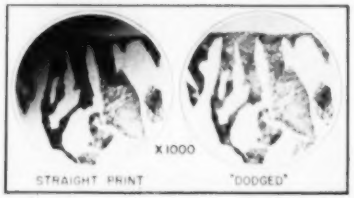
ON EYEPIECE ON FILM

EFFECT OF FINGERPRINTS



ON EYEPIECE ON OBJECTIVE

CORRECTING UNEVEN ILLUMINATION



STRAIGHT PRINT "DODGED"

Sheet IV of Six Prepared by Research Laboratory, U. S. Steel Corp.

Reproductions herein have been reduced to about one third the original magnifications noted; See also "Metallographic Technique for Steel", by J. R. Vilella, published by The American Society for Metals

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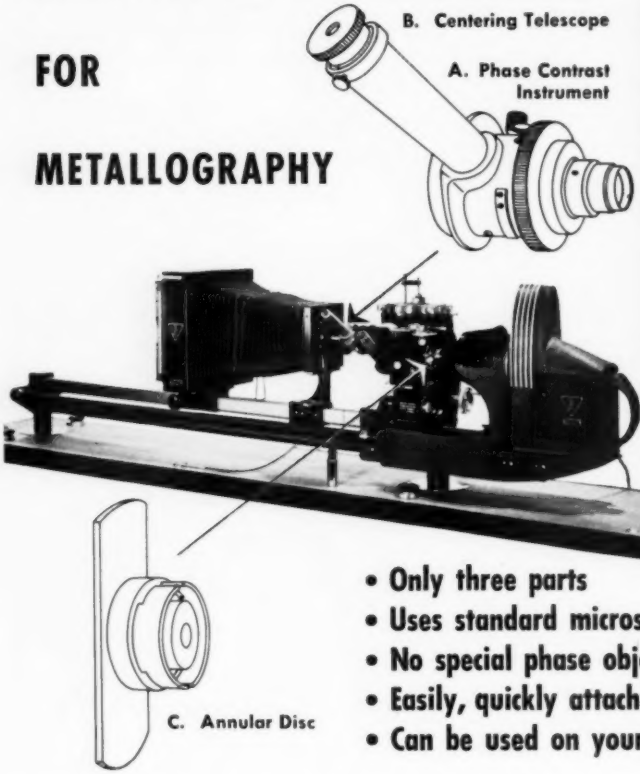

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Critical Points

By The Editor

The Navy's Guest

RADIO commercials have overworked all the superlatives in hymning the thrills of smoking Cameluckold cigarettes, so there are none left for THE EDITOR to describe the exciting ten hours preceding the formal presentation by Commander H. C. LAUERMAN, on the deck of SS-475, of a little card notifying all good sailors of the seven seas that ERNEST E. THUM is an Honorary Submariner. We had left New London shortly after dawn, a crew of seven officers and 80 men, 20 reservists along for training, and three civilian guests. SS-475, the U. S. Submarine Argonaut (a veteran of long service in the Pacific), played hide and seek with a sister ship out in Long Island Sound. First one would submerge and attack while the other sailed an evasive zig-zag course, and then the roles would reverse. In four such practice runs 16 dummy torpedoes were discharged; whether we were theoretically sunk had to await analysis next day of the ships' logs and charts plotted by dead reckoning and by radar and sonic courses and ranges. As though these maneuvers did not tense sufficiently the honorary submariners aboard, the Argonaut made several dives with student sailors at the controls, and on one extra deep one a single electrifying squawk on the speakers sent every man bolting to emergency stations, the bulkhead doors slammed shut and locked, and we waited ("scared" is the word to describe the way one man felt) for news which when it came was in no way reassuring: "Water entering conning tower", the ship's general headquarters. While the temperature got hotter and stickier and more oppressive, and sweat poured freely, we waited, trapped in the officers' ward room (nautical name for breakfast nook into which seven can crowd) until finally the ear drums crackled and a marvelous rush of fresh air burst through the ventilators, showering everything with dust — a vacuum cleaning in reverse that dismayed the mess boy. However, THE EDITOR gave thanks for the stout hull, the rugged machinery, the mysterious controls and the well-disciplined men who handled the matter as one of routine (an attitude belied by the soot on the ward-room tablecloth).

As those who have read these "Critical Points" for years past may remember, THE EDITOR has commented on many items of ship construction — primarily noting how excellent metal is fabricated and welded and treated and finished, then put into hulls, guns, engines, propellers, valves, pipe, magnetic and electric devices, ranging all the way from tiny gyroscopes for steering torpedoes to long periscope tubes of polished stainless steel. But it's one thing to see these items in various shops, or even being assembled on the ways; quite another to observe the workings of the completed ship, a marvel of compact efficiency, second only to the human crew which mans it. One is tempted to make a comparison with the airplane — a machine that is more familiar to JOHN CITIZEN, at least superficially. The Argonaut is on the same order of size as the biggest air liner or bomber's fuselage, and both submarine and airplane float in a fluid medium, the one in a dense medium, water, the other in a rarefied medium, air. The submarine is lighter than the medium it displaces, hence tends to float; the airship is heavier, hence tends to land. But then the parallel must stop. It can be continued a little further if we compare the submerged submarine to a blimp. Both maintain their elevation by an exact balance between weight of ship and fluid medium displaced. But otherwise there is little in common between submarine and aircraft. Most of its equipment is housed in a welded steel cylinder with a blister on top, shaped much like an old-fashioned steam boiler, only it is 18 ft. in diameter and 300 ft. long, and designed to resist collapse at 300-ft. depth (150-psi. external pressure; with a good factor of safety). Inside this cylinder is the power plant, 6400 hp. in four diesel engines, two generators, two motors driving each its own propeller. (Also below decks are carloads of great storage batteries, each as big as a filing cabinet, to take over from the diesels when the ship is submerged.) In the engine room are many auxiliaries, such as pumps for water, oil and air, water stills, air conditioners, refrigerating units for the food lockers. Inside this cylindrical main

structure of the ship are also 10 torpedo tubes and a couple of dozen torpedoes — each a fast submarine itself. Fitted in among the engine, control and torpedo rooms is space for 90 men to eat, sleep and wash, food lockers for seven or eight weeks plus some emergency rations; a kitchen and a pantry. Also coffee Silexes on convenient hot plates as well as ammunition for the deck guns; communications (inside telephones, speaking tubes and signal systems, plus radio, radar, and sonic signaling — "asdics" — for the outside). Large banks of control equipment exist in bewildering variety, much in duplicate and some even in triplicate in the conning tower, in the control room below and water-proofed on the bridge. For this ship has much more to do than the ordinary motor ship which just floats and is steered ahead by propellers and rudder — it must also sink at demand and move along at any desired depth, delicately poised between rising to a surface searched by enemies or sinking down to DAVY JONES's locker. This constant balance in all directions is maintained by sucking in or blowing out water in tanks *outside* the pressure cylinder; indeed a complete outer hull is compartmentalized for this purpose (as well as to hold the fuel oil).

Innumerable metal problems have been solved in this vast array; the very limitations of weight and space mean that each part must be refined for highest performance; safety of near hundred men demands absolute reliability. In battle the submarine plays the cat-and-mouse game; its safety rests in hiding, yet it must be able to withstand the racking shock of depth charges or near-miss bombing. In ordinary evolutions the greatest hazard comes from the numerous hatches and inlet and outlet ports through the pressure cylinder — failure of a 1-in. cock when deep diving would be near-mortal. Then there is the problem of corrosion, especially in inaccessible ballast tanks where air and salt water get in their dirty work. (Probably here the new sonic devices for testing soundness of metal can measure the distance to the inner surface, just as its cousin fathoms the sea or locates distant ships.)

The war record of the submarine is praiseworthy indeed. One recalls the constant theme of WINSTON CHURCHILL's writings — that the German submarines came within an inch of winning both world wars. In our own Pacific operations, the U. S. Submarine Force, with 1.6% of the personnel of the whole navy, sank 29% of all the Japanese men-of-war. As for the future, the well-known "snorkel" will enable the sub to cruise indefinitely at periscope depth, almost completely hidden from radar or aircraft search; improved engines will increase its submerged speed to where asdic detection becomes almost impossible. So, all in all, the feeling this horseback-riding metallurgist carried away from his brief excursion on this grimly efficient vessel is one of satisfaction that his professional brethren are responsible for metal products that are basic to all its mechanisms, worthy of trust, true as steel.

Atom Hunters

TO Washington, for a meeting of engineering editors with the Atomic Energy Commission's staff to discuss ways and means of releasing valuable information now locked in "secret" files, potentially valuable to peacetime industry yet not revealing anything about the atomic bomb or its manufacture. Such action is mandatory by law. A major obstacle, quickly revealed, lay in this very matter of secrecy. How can one tell whether documents exist as long as they are secret, cannot be examined?

While there, we were shown some smudges in the bottoms of glass bottles — samples of elements 43 and 61, formerly missing from the periodic sequence, but now separated from the fission products of uranium in the Oak Ridge pile. Chemists have already claimed discovery of both, but such claims have never been verified. Both are radioactive; element 43 has a relatively long half-life so its illusiveness must be ascribed to its extreme rarity. (But why is it rare?) Element 61 has more interest because of its associations. It is one of the "rare earths" — elements 57 (lanthanum) to 72 (hafnium) — elements so alike chemically that separation is exceedingly difficult. They occur mixed up in certain rare minerals, some in infinitesimal amounts. Chemical processes are almost as powerless to identify them as they are of separating isotopes.

Perhaps some romancing biographer will popularize the fascinating search for element 61, finally hunted down at Oak Ridge during the war by two soldier-scientists, J. A. MARINSKY and L. A. GLENDENIN, and named "promethium" after the legendary giver of fire. One gram is produced there every 60 days. It has the very short half-life of 3.7 years, so in a cosmic sense it is quite evanescent; it is created only to decay. No wonder the chemists couldn't find it! The chance that promethium $_{61}Pr^{147}$ may have a *stable* and hence an enduring isotope, or any isotope of any sort, is rather slim if you can bet on an analogy. Thus: All the even-numbered rare earths from 58 to 72 have four to seven isotopes, but all the odd-numbered ones have but one (except 63 and 71, which have two).

The Physics of Powder Metallurgy

Reported by F. V. Lenel
Dept. of Metallurgical Engineering
Rensselaer Polytechnic Institute
Troy, N. Y.

A THREE-DAY symposium on the physics of powder metallurgy, organized by the metallurgical laboratories of Sylvania Electric Products, was held in Bayside, N. Y., in August. Twenty-three papers were presented by metallurgists and physicists from this country and abroad before an audience of invited guests, who participated in a lively discussion of the papers. It is planned to publish both the papers and discussion in book form. Nine of the papers were experimental or analytical contributions to the theory of sintering, which, at present, is in the forefront of powder metallurgical interest. Eight papers were concerned with grain structure and diffusion problems that are closely connected with the theory of sintering. The remaining six papers presented new experimental data or reviews on various practical problems of powder metallurgy.

The lead-off paper was a joint contribution by W. E. Kingston, manager of Sylvania's metallurgical laboratories, who acted as chairman of the symposium, and by G. F. Huettig of the Technische Hochschule, Graz, Austria: "The Fundamental Problems of Sintering Processes". The authors presented a review of their concepts regarding the mechanism of sintering of single metals. It was shown that the surface energy of a metal crystal can account, at least in a qualitative way, for the motivating energy of the sintering process. Different kinds of movements of atoms and of atomic aggregates were distinguished which may contribute to the sintering process. These atomic rearrangements were defined as self-diffusion, which, in the authors' terminology, includes any movement of atoms in a metallic medium rather than only the migration of atoms under a concentration gradient. In a section on the kinetics of sintering, Kingston's theory of the formation of recrystallized nuclei during compacting at room temperature and Huettig's concept of sintering as a rate process were emphasized.

Three papers were experimental contributions to the theory of sintering for single metals: "The Rate of Shrinkage of Synthetic Pores in Copper", by A. W. Postlethwaite and A. J. Shaler; "Relations Between Diffusion and Viscous Flow in Metals", by B. H. Alexander, G. C. Kuczynski and M. H. Dawson; and "The Electrical Properties of Sintered Materials as Indicators of the Degree of Sintering", by H. H. Hausner and J. H. Dedrick. Postlethwaite and Shaler observed the decrease in volume of an artificial pore, consisting of a hole drilled in a copper wire, during sintering at 1830° F. Their data, designed to establish the fundamental mechanism of densification in powder compacts, are consistent with a mechanism of viscous flow in which the strain rate is proportional to stress. Messrs. Alexander, Kuczynski and Dawson reported on two series of experiments. In the first series, copper wires wound on heavy copper cylinders were heated for increasing lengths of time at 1920 and 1960° F. The measured increases in contact area between wires and cylinders are interpreted as being caused by a mechanism of self-diffusion of lattice vacancies. In the second series, the creep of gold wires was observed at 1920° F., at which temperature the wires exhibit viscous flow. Both diffusion and viscous flow are considered to proceed by migration of lattice vacancies — in diffusion this is accomplished under the influence of the stress produced by surface tension; in viscous flow, under the influence

(Continued on page 570)

By Gladstone Keir
Process Engineer
The C. M. Kemp Mfg. Co.
Baltimore, Md.

Efficient Heating of Descaling Baths

WIDESPREAD use of the sodium hydride descaling process and other molten salt baths often creates the problem of selecting the most efficient method of heating. Much has been written concerning gas-fired immersion heating. There remains to be presented information about recirculating heaters fired with an accurately proportioned air-gas mixture. A typical cross section of such a descaling pot and its heaters is shown in Fig. 1. Figure 2 shows the recirculating heater.

Several factors affect the rates of heat transfer from the flame and combustion products to the heater walls and thence to the molten salt. The coefficient of heat transfer from a solid to a liquid is much greater (30 to 1000-fold, according to William H. McAdams in his book, "Heat Transmission") than from gases to a solid, so that the greatest resistance occurs on the inner surface of the heater. It is an extremely important fact that, if the partial resistances to heat transfer differ greatly in magnitude, only the largest resistance will have a significant effect on heat transmission.

We believe that the recirculating immersion heaters, fired with carbureted gas at comparatively high pressures, provide the best means for improving heat transmission *within* the heater. Since the greatest resistance is occasioned by the laminar film on the inside of the tube, the greatest single factor in overcoming this is to obtain a high velocity of flame and combustion products, to reduce this film resistance.

Figure 2 shows in detail how this is accomplished. Accurately premixed gas and air are delivered to the burner at a fairly high pressure and provide a long, driving flame in the center of the heater tube. Recirculating combustion gases are entrained by the jet action of this flame, thus providing a large volume at high velocity, obtained without the heat loss of the other methods, which depend upon excess air introduced by a blower, inspirator or suction fan. Heat from that portion of the combustion products which passes out the heater stack is further reclaimed in part by transfer to the incoming gas-air mixture, raising its temperature before it gets to the point where combustion takes place.

Not all of the heat is transferred to the heater by conduction, since some radiant heat is released from the carbon dioxide and water vapor in the hot products of combustion.

Heater Construction — Immersion heaters for sodium hydride and other noncorrosive salts for temperatures up to 1000° F. are constructed from a good grade of low-carbon steel. Corrosive material and higher temperatures require special materials of construction for specific conditions. Immersion

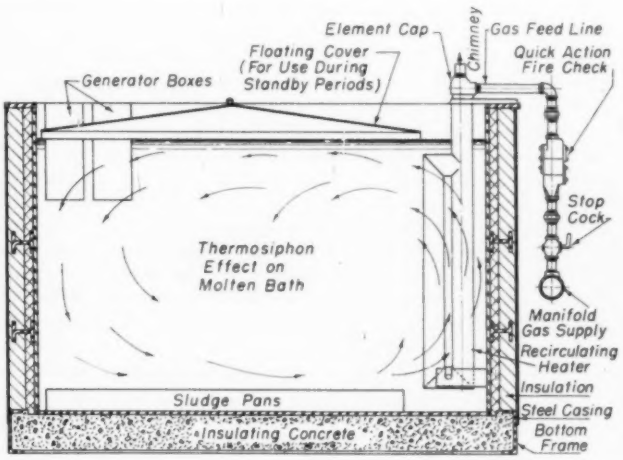


Fig. 1—Cross Section of Typical Salt Bath With Immersion Heaters

heaters have long life, but when they do fail they are easily removed and replaced while the pot continues in operation.

Since the pot itself is not subjected to high temperatures, failure of this component does not occur. Compared with externally fired pots, immersion heated pots are constructed of lighter plate. Complete insulation of sides and bottom improves the thermal efficiency. The construction outlined has one other great advantage in that working conditions for plant personnel are greatly improved by temperature reduction and the absence of dangerous carbon monoxide fumes. Where large volumes of work must be processed in a continuous operation, these factors are of the greatest importance.

Excellent heat distribution is obtained within the molten bath due to the thermosiphon set up by the difference in density of the heated salt, as indicated in Fig. 1. This natural convection also transmits heat quickly to the cold work entering the bath. Very close temperature control is obtained; time lag and temperature overshoot, so common in underfired pots, are eliminated. Long pots should be zoned for more effective temperature control.

Before the first installation of this kind was made in a sodium hydride descaling pot, extensive tests were conducted, and the results indicated that recirculating immersion heating would offer

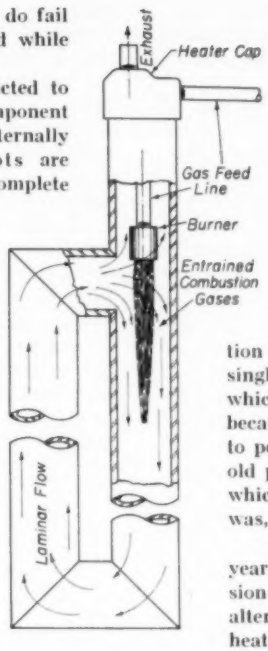
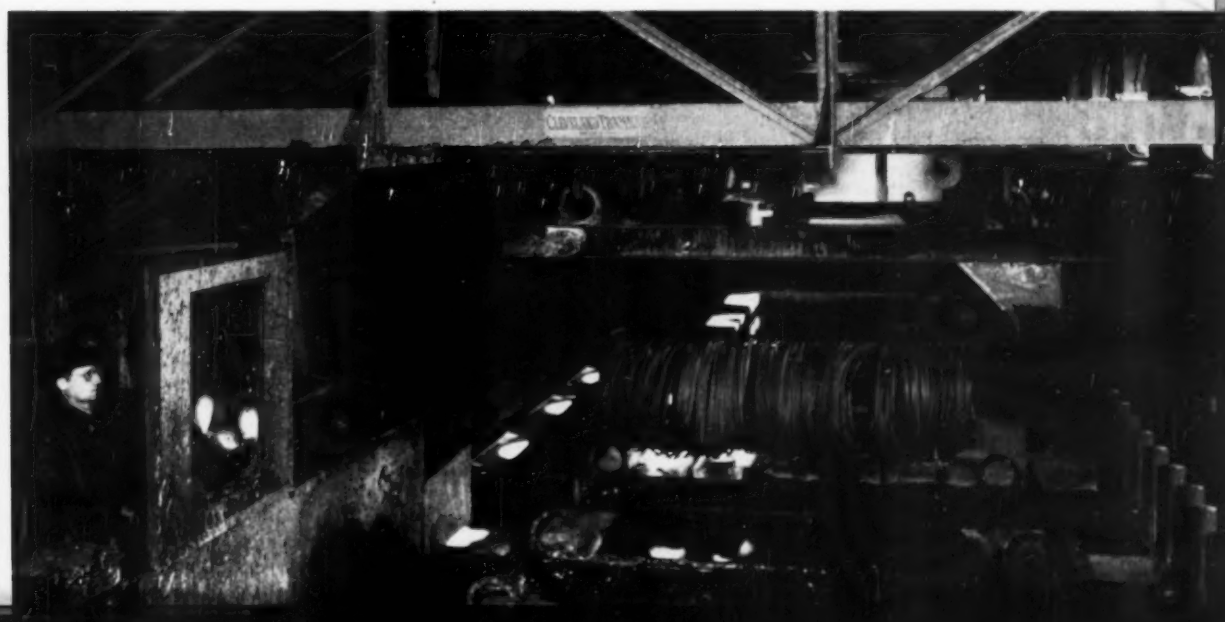


Fig. 2—Construction of Recirculating Immersion Heater

the same efficient performance as in the melting of lead or tin, or in other similar applications which have been most successful.

A large sodium hydride descaling bath in use in a stainless steel mill is shown in the illustration at the bottom of this page; charging boxes are located so that long rod and tubing can be treated in addition to rings or rolls of wire and strip. This single pot replaced two externally fired units which had been used for alternate charges because temperature recovery was too slow to permit using one unit efficiently. These old pots were frequently in need of repair, which caused costly delays. Fuel efficiency was, of course, very low.

Another installation, made about two years ago, replaced the usual type of immersion fired pot. Formerly two pots were used alternately, one being a spare for use while heaters were replaced in the other. Although more than ample heat was available, it was utilized so inefficiently that processing had to stop for extended periods to permit the bath to regain temperature. Also, due to wide temperature fluctuations, too much of the work had to be reprocessed. This one bottleneck was restricting the output of the entire section. Installation of a single pot, heated by recirculating heaters and carbureted gas, provided ample facility for day-to-day operation and quickly processed the backlog



of accumulated material. Since the manufacturer sought primarily increased output and decreased maintenance, the fuel saving obtained offered additional satisfaction.

The accurate proportioning and mixing of the gas and air are most important. Gas, from the main, after passing a gate valve, goes into a pressure reducer and governor and thence into a proportioning valve. Filtered air meets it there, and the two gases are drawn through the proportioning mechanism into a turbocompressor. Equipment between turbocompressor and heaters consists of backfire check, pressure gage, and test burner.

The carburetor is so designed that after the initial setting is made no further adjustment is necessary. Regardless of demand, the air-gas mixture is automatically supplied at constant pressure. The result is that burners operate with predetermined flame characteristics and at uniformly high efficiency. Power consumption is low and proportioned to the demand for gas. During standby periods, therefore, a minimum of power is required.

Conclusions — Years of experience and direct comparisons of fuel and maintenance costs have proved that immersion heating with recirculating heaters and premixed gas offers superior performance and marked economy except in locations where electric power is very cheap. It has also been adequately shown that unsatisfactory heating arrangements can nullify the excellent results obtainable from the sodium hydride descaling process and from other salt bath cleaning and heat treating processes.

Where consideration is being given to a new salt bath or when present installations are not producing economically, engineering and management will find it worthwhile to scrutinize the heating arrangements carefully.

Economy in Fatigue Testing

By M. G. Corson
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New York City

DETERMINING the fatigue limit of a metal is a time-consuming process. There is need for a systematic method of analysis that will decrease the amount of testing, especially the number of specimens run for more than 10 million reversals of stress. As an aid to economy in fatigue testing, I have developed the following equation:

$$N = \frac{A}{(S-K)d^{(S-K)}}$$

In this equation, first published in *The Iron Age*, March 10, 1949, S and N have their familiar meanings (stress and number of cycles to failure), K is the maximum safe stress in fatigue, and A and d are constants. The term $(S-K)$ represents the overload above the safe stress and is expressed in thousands of psi. in the formula.

Three pairs of S-N values are required in order to evaluate the three constants K, A and d, for a given S-N curve. To illustrate the results of calculation, I have used the data on fatigue of titanium published in *Metal Progress* for March 1949. Figure 1 shows the S-N curves for four series of experiments, and on each of the experimental S-N curves are indicated the pairs of values (S_1,N_1; S_2,N_2; S_3,N_3) used in evaluating the constants K, A and d. (The values of S_1, S_2 and S_3 were selected to cover equal increments of stress, because the equation can be solved for K algebraically if the increments are equal. Otherwise, one has to assume a number of values for K, compute the corresponding S or D by pairing the equations, draw the K-d or K-S curves and take their intersectional values for the true K and d, or K and S.) As shown by the horizontal arrow in the lower left part of each graph, the calculated safe stress K is in reasonable and conservative agreement with the experimental values for the specimens stressed for the greatest

number of cycles. For the four sets of data shown, the constants have values as follows:

	A	d	K
I (top)	964,000	1.044	29,700 psi.
II	14,900,000	1.109	14,500
III	4,420,000	1.025	16,600
IV (bottom)	3,030,000	1.090	24,200

The formula applies to ferrous as well as nonferrous metals. For instance, consider Fig. 2,

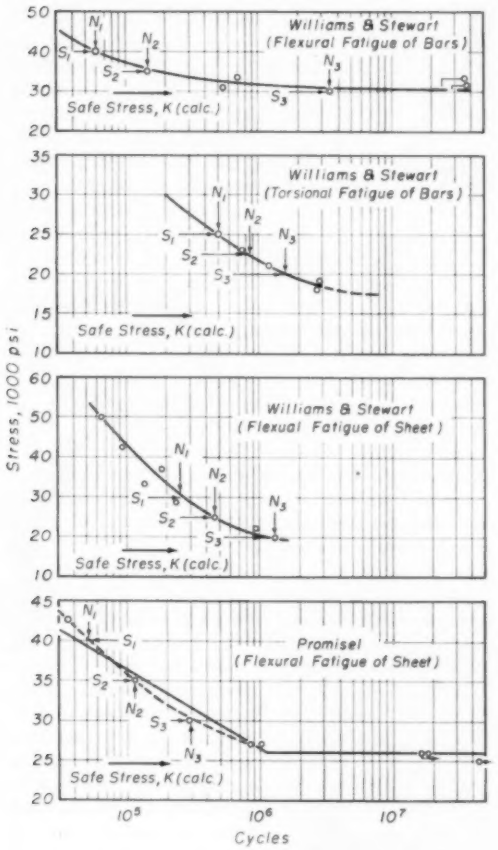


Fig. 1 — Comparison of Calculated Safe Stress With Experimental Fatigue Data for Titanium

which shows the *S-N* curve for a normalized carbon steel, as determined by H. F. Moore and J. B. Kommers (Bulletin 124, Univ. of Illinois Experiment Station, 1921). The data for this steel are unusually complete and consistent, and the experiments extend to 100 million cycles. Therefore, this curve offers a particularly good opportunity for checking the formula. Using the three sets of *S-N* data indicated on the graph, the safe stress K is calculated as 41,200 psi., in comparison with the experimental value of 42,000 psi. This is an especially striking confirmation because the values of N_1, N_2 and N_3 corresponding to the stress values selected were 30,000, 90,000 and 400,000 cycles — all well below the experimental maximum of 100,000,000. This means, then, that accurate experimental determination of these three points would give the entire *S-N* curve accurately for this steel, without prolonged testing. If nine specimens were tested at S_1, six at S_2, and three at S_3, a total of 2 million reversals might be required to obtain a reliable set of three pairs of *S-N* data for this steel. If two fatigue machines of 3000 reversals per minute were used for testing, the 18 specimens could probably all be run in one day. Then, after the safe stress K was calculated, one or two specimens could be run for a week under a stress

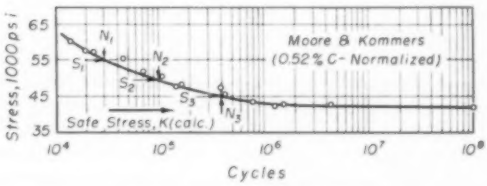


Fig. 2 — Fatigue of Normalized Carbon Steel

slightly less than K, in order to check the validity of the calculated safe stress.

Although all the data necessary for calculating this particular *S-N* curve might be obtained in a single day's testing, it is not to be expected that such a short period would be sufficient for any *S-N* curve. However, assuming that the suggested equation is correct, it would never be necessary to run individual tests into many millions of cycles. Even allowing a 50% loss of time for changing test pieces, one week should suffice for a very complete test that would permit the construction of minimum, maximum and average *S-N* curves and the corresponding equations. If fatigue testing could be confined to stresses that cause failure in less than 10 million cycles, there would be a greater opportunity for studying such factors as surface condition, notches, and the speed of testing.

I have checked the suggested equation for numerous published data concerning all the industrially important classes of alloys. The results have been consistently accurate, within the experimental uncertainties of the original data.

By William A. Patzer
President and Chief Engineer
A. B. T. Manufacturing Corp.
Chicago

Hitting the Bull's-Eye With Precision Castings

As a manufacturer of automatic coin-controlled mechanisms for 25 years, we've had our share of design and production problems, particularly in relation to Mr. John Q. Public, who is as honest as the day is long until he faces a vending machine. Psychologically, a vending machine presents something of a challenge, and many and ingenious have been the schemes to extract the merchandise or service from the machine with slugs, buttons and other nonmonetary objects. We believe, however, that we have this particular problem licked. Our automatic mechanisms now weigh the coins, measure the size, and even check the metallic content of the coin offered — all in the twinkling of an eye.

We recently had a serious problem of another type, involving castings on one of our new products, a rifle range unit for amusement parks, carnivals, bazaars, and the like. On this particular unit, the rifles fired steel pellets by compressed air, which could be furnished from a standard air compressor or a cylinder of CO_2 gas. We called it "Rifle Sport", and showed a sample unit at one of the trade shows. It proved to be a popular item and we wrote a considerable number of orders.

We had difficulty with the aluminum sand castings in our initial production run. Rejections ran high, resulting from porosity and deep pits encountered when the castings were being machined. Only 25% of all parts supplied were acceptable for use. We had particular trouble with those castings which were used to fasten the wooden stock to the barrel of the gun (Fig. 1) and those which fitted on the muzzle and formed the lead sight (Fig. 2). This latter casting formed the end of the barrel, and had a cone-shaped interior which amplified the sound and simulated the firing noise of a regulation rifle. In our tests under actual conditions of strenuous use, the boss of the aluminum casting in the gun stock did not have required strength and a considerable number broke. Replacement was not only expensive, but constituted a considerable annoyance to our customers. A perfect fit of replacements was also necessary as an air leakage would lessen the power and accuracy of the gun, and we had not been successful in obtaining aluminum castings to close enough tolerances to permit interchangeability of parts. We had other problems with our castings as well. Our trigger (Fig. 3) and trigger guard (Fig. 4), aluminum castings, had to be filed and polished. It proved to be virtually impossible to remove the file marks, and the parts were hard to hold during machining. The barrel casting was extremely difficult to machine accurately; for that reason and because of foundry defects (pits and porosity), our rejects ran as high as 75%. Our cost situation was unfavorable on these castings, too, because of the high cost of the machining that had to be done before the gun could be assembled.

Fig. 2

Fig. 3

Fig. 1

While these castings were being milled, additional costs were encountered because internal flaws in the castings were exposed, necessitating our scrapping approximately 25% of the partially machined castings.

We were obviously working with the wrong metal and the wrong method of fabrication. With new orders coming in and a considerable backlog still on the books, we had to have a fast, practical solution to a very serious problem.

We decided to attempt using precision castings and contacted Austenal Laboratories, Inc., the originators of the "Microcast Process" of precision investment casting. We met with Austenal engineers and agreed to try their production method on the four casting pieces previously mentioned, together with the bolt-action lever (Fig. 5) and the rear-sight casting (Fig. 6). Time was important, and we impressed upon Austenal the necessity for speed. It was decided that carbon steel (C1117) would be the most advantageous alloy for us to use. Austenal produced samples to our specifications within ten days. These were immediately approved, and two weeks later we had our first production shipment on all six pieces. It was one of the fastest deliveries of parts, from blueprint to finished units, that we have ever experienced.

Fig. 5

Fig. 4

These precision castings exceeded our highest expectations. They eliminated all machining operations except the drilling and tapping of holes. The close dimensional tolerances held and the smooth finish obtained enabled us to assemble the parts in the as-cast condition.

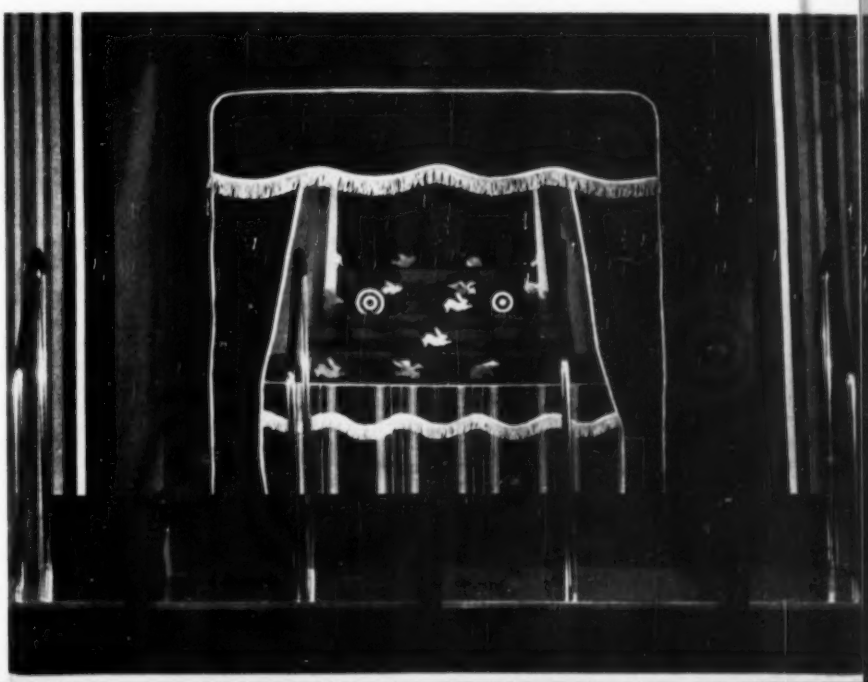
The Microcast process saved us from 50 to 60% on the cost of finished parts. To give you an idea of what this percentage meant when translated into dollars and cents, we arrived at the following breakdown of costs for the casting shown in Fig. 1, which was used to fasten the wooden stock to the barrel of the gun.

Our costs on the aluminum casting that was used originally for this part ran 60¢ each for the raw castings. Besides this cost for material, however, we had to expend an average additional milling cost of

Fig. 6

$4.50, making the cost of each of these finished castings run up to a total of $5.10. But even at this cost, the original parts were not up to the standards required. Our Microcastings of the same part were to close dimensional tolerances, as cast, and no milling was required. Our cost for the part as produced by Austenal's precision investment casting process, complete with the exception of a small additional expense for the drilling and tapping of holes, was only $2.50, representing a saving of slightly more than 50%, which was obtained on our other castings also. Substantial as this saving on the cost of the finished parts is, it was only the beginning of the economy we realized as a result of this particular change in manufacturing procedure. Efficiency of operation was increased 120%, our service calls in the field were reduced 135%, the life of the gun was increased 300%, and our efficiency of production was increased 280%. Only through the use of Microcastings were we able to produce and market a gun that would stand up under actual operating conditions.

The next time you're at an amusement park you might have a try at one of our "Rifle Sports". But if you don't hit the "bull's-eye", you can't blame it on the gun. They're all operating perfectly now.



Effect of "Strategic" Bombing

Unstrategic Bombing

IN AN ARTICLE on "Unstrategic Bombing and World Ruin" in *Ordnance*, Sept.-Oct., 1949, Maj. Gen. J. F. C. Fuller, retired, of the British army writes as follows:

If we fight for certain moral values which we hold dearer than life itself — then, whatever our enemy may do, we dare not set them aside. It must never be overlooked that the permanent victory is the moral one. Each infringement of the principle of right action is a step toward moral defeat and each adherence a step toward moral victory.

We cannot wage war without injury to our common civilization, for physical war in its very nature demands economic destruction. That in war we must wound our civilization is certain; but should we wound it mortally, we shall perish with it. Therefore, in depriving our enemy of his industrial war power we must do our utmost not to inflict a mortal wound on our common civilization.

As General Sherman once said, "The legitimate object of war is a more perfect peace." Such a peace is impossible if during a war we jettison the very principles we say we are fighting for. Victory in itself is not sufficient; for to "win" and be engulfed in a common ruin is insane.

It is clear from the above that the so-called strategic bombing resorted to in the recent war will not foot the bill. The people responsible for its adoption were not the airmen but the statesmen. The Casablanca Conference categorically laid down that the aims of strategic bombing were "the destruction of the German military, industrial, and economic system and the undermining of the morale of the German people".

The method employed is described by Sir Arthur Harris, in whose hands British strategic bombing was entrusted. To quote his words:

"The aiming points were usually right in the center of the town . . . . which was naturally more densely built up than the newer and well-planned suburbs; it was this densely built-up center which was most susceptible to area attack with incendiary bombs." I hold that this type of bombing is unstrategic. I am opposed to obliteration bombing carried out either at short or long ranges — in the first case without reference to the eventual movement of troops, and in the latter without reference to the political aim.

Strategic targets are of two main categories — the sources of industrial and military energy, and the means of industrial and military movement. In other words — coal, oil, and transportation. If these could be steadily crippled, eventually the bulk of the enemy's factories, railroads, and all gasoline-propelled machines and vehicles would come to a standstill. Then, at long last, "strategic" bombing would become strategic, and a defeated country would not end by becoming a scarlet jungle.

Hiroshima — Four Years Later

NORMAN COUSINS, editor of *Saturday Review of Literature*, has this to say on the above subject in his issue for Sept. 17:

This is about a visit to Hiroshima. Hiroshima today is vital. It has been completely rebuilt — rebuilt, that is, on a sort of overnight basis, very hastily. But the greatest difficulty hasn't been putting up the new buildings and shacks. The greatest difficulty has been clearing away the rubble.

I spoke to many people, asking what they thought of the bomb and about America. There was no bitterness, except in one or two cases. They believed, most of them, that two years of blinding, grinding warfare were squeezed into a single bomb and that the smashing of Hiroshima made it possible for many millions of Japanese to stay alive, for they then knew by this bomb that the war was forever lost to them.

Some blamed it on the Japanese Government because it had converted Hiroshima into a military base and shipping point. This was the first I had heard about it as a city of military importance. SHINZO HAMAI, the mayor, spoke freely and fully. Hiroshima had been Japan's chief port for sending soldiers overseas. It had housed large ammunition supply depots. I learned that 30,000 soldiers had died in the atomic bombing and that this figure had been suppressed to conceal the general damage and civilian death toll. "The city's own estimate today of its dead," said Mayor Hamai, "is 210,000 to 240,000." The highest previous figure made public was 100,000.

A tour of Hiroshima's hospitals was an experience difficult to put out of your mind. Nothing you have seen in Germany put human pride to such a strain. Everything is needed that makes a hospital a hospital — surgical equipment and medicines and rubber gloves for operations and sterilizers and X-ray equipment and beds and pots and pans.

The Yamashita Orphanage for children whose parents were killed in the atomic explosion was, I think, the high spot of my visit; living conditions were better and brighter than I had seen anywhere else in the city. The food was adequate and well prepared; there was ample play space; and, what was more important, the children were not starved for want of affection. There was only one thing wrong with it. It ought to be five times as large, and would be, if outside help were forthcoming.

The full cost of taking care of one child at the Yamashita Orphanage — including food, education, and everything — is $2.25 a month. If any reader of these words would like to provide for Hiroshima orphans on this basis, I should be glad to act as middleman.

[NOTE to all readers of *Metal Progress* who may be interested: Mr. Norman Cousins' address is 25 West 45 St., New York City, 19.]

By J. S. Gillespie
Carboloy Co., Inc.
Detroit

Increased Use of Hard Carbides for Wear Resistance

INCREASED utilization for parts other than cutting tools has been one of the interesting developments in connection with the ultrahard metals such as cemented tungsten carbide. The use of carbides has now reached into numerous fields of application — textiles, machinery, household items (such as knife sharpeners and paint scrapers), sporting goods (such as fishing-reel bearings and fishing-rod guides), and others.

The machine tool industry, however, still remains the leader in the application of these metals at "wear points" to increase life and reduce service difficulties. This is not surprising, of course, since the machine tool industry is more familiar than others with the potentialities of the tungsten carbides, as a result of their experience with these metals in the form of cutting tools.

A typical example of the numerous uses in just one narrow field is in connection with grinding equipment; applications range all the way from lining molds for the forming of grinding wheels through various machine parts to the truing of the grinding wheels themselves.

Hardness is not the only physical characteristic that has led to the use of carbides, although hardness is a major factor. Commercial grades of Carboloy cemented carbide, for instance, have a Rockwell hardness of A-85 to 93, giving them extreme resistance to penetration and scratching. In addition, carbide metals have a modulus of elasticity more than double that of steel, a tensile strength equal to about one half that of tempered toolsteel, and extreme resistance to wear caused either by friction or the abrading and gouging action of grit and other abrasives.

Some of the uses of tungsten carbides in the grinding field are described in the remainder of this article.

Abrasive-Wheel Mold Linings — "Wearproofing" of steel molds with a carbide lining (see Fig. 1 on the next page) has increased the life of molds, such as are used for forming abrasive wheels, as much as 10 times. According to one manufacturer of abrasive products it has been found that, in addition to increasing mold life, the wheels are more easily removed from these molds because of the ability of the carbide metal to retain its high finish for long periods. Reduced breakage of the wheels while they are being removed has been a result.

So far, this type of mold is still used mainly to make the smaller sizes of mounted abrasive wheels and the "points" used on small, high speed grinding machines, although some experimental work has been done on larger molds. No alteration in mold design — or in top and bottom plunger parts — was required when changing from all-steel to carbide-lined types.

The carbide-lined molds have already produced more than 10,000 units each — about 10 times the life of all-steel molds — and no barrel has worn out yet.

Machine Ways — Bearing surfaces of carbide against carbide — formed by installing carbide dovetail ways and wear strips on precision grinders — have apparently eliminated maintenance expenses on ways and the downtime previously required to maintain such machines in the condition required for diamond wheel grinding. Among products produced on a typical grinder of this type are carbide form tools, carbide rolls up to 5 in. diameter for steel mills, and various sizes of wire guides. The cast-iron ways and gibs originally used on these machines had to be removed

and scraped back to a plane surface once every four to six months under the severe grinding conditions imposed. Between scrapings, frequent adjustments had to be made to counteract wear.

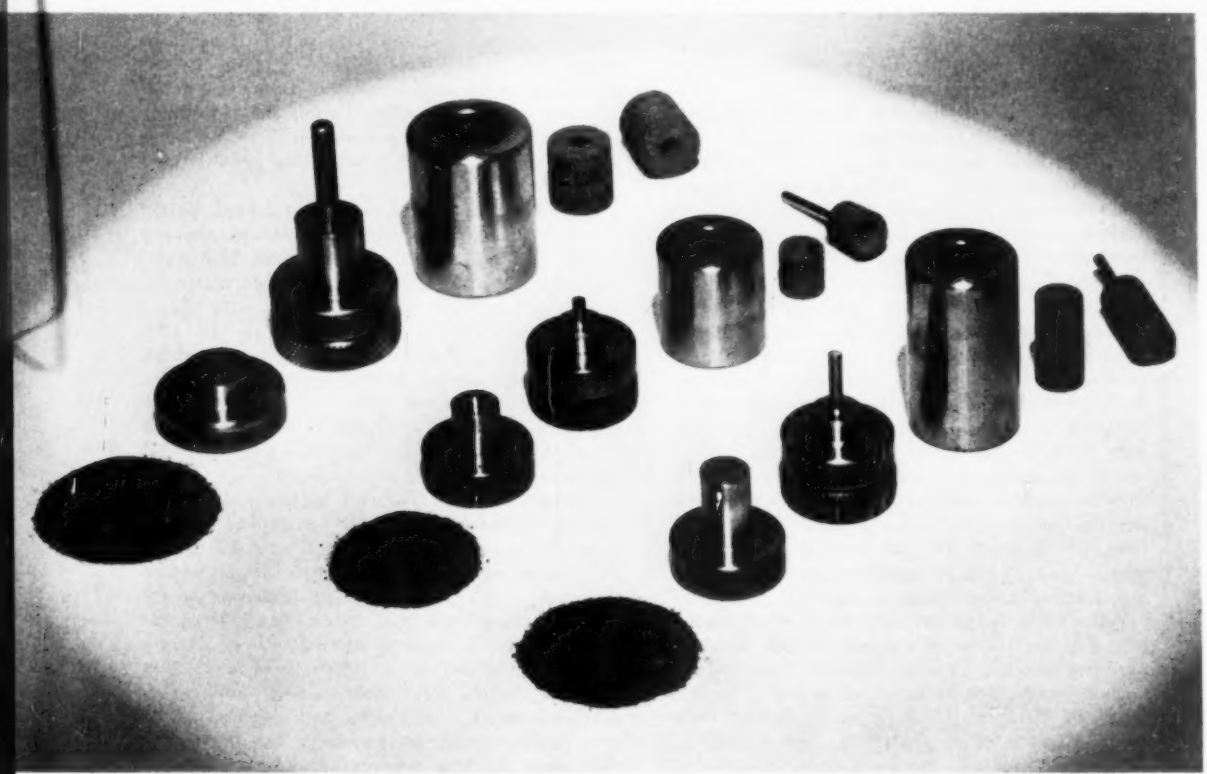
The carbide ways consist of two upright dovetails, each about $9\frac{3}{4}$ x 1 x $\frac{1}{2}$ in. Bearing directly against the dovetails are two carbide inserts — $8\frac{1}{2}$ x 1 x $\frac{3}{16}$ in. — on one side of the head, plus a tapered gib on the other. Thus, all bearing surfaces in the grinder are of solid carbide metal. These ways have been in continuous use, two 8-hr. shifts per day, since their installation in July 1947. No signs of wear have as yet been detected, and the grinder has not been down for maintenance of the ways or gib.

Centerless-Grinder Rests — Wearproofing of centerless-grinder rests by brazing from one to four carbide strips along the length of the rest is now quite common. One large producer of grinding equipment now recommends carbide blades for centerless grinders for the majority of materials to be ground, and specifies them as a necessity for grinding stainless steels. The carbide rests are reported to be giving anywhere from 30 to 350 times the service life of similar high speed steel rests under similar conditions. The carbide strips are usually rectangular in cross section, averaging $\frac{1}{8}$ x $\frac{3}{8}$ in. Common practice is to hold individual pieces of carbide to a maximum length of 6 in. where feasible. In some machines, however, carbide sections as long as 42 in. have been applied successfully.

In one typical instance, production records show that the carbide-protected rests averaged as many as 575,000 pieces between reconditionings as compared with an average of 1600 for the high speed steel rests formerly used on the same operation.

In another operation, 200 lots of pieces ranging in size from 1 in. down to $\frac{1}{16}$ in. diameter were

Fig. 1 — Lining the Mold Barrels for Forming Abrasive Wheels With Cemented Carbide "Bushings" Has Greatly Reduced Wear and Multiplied Mold Life From 5 to 10 Times



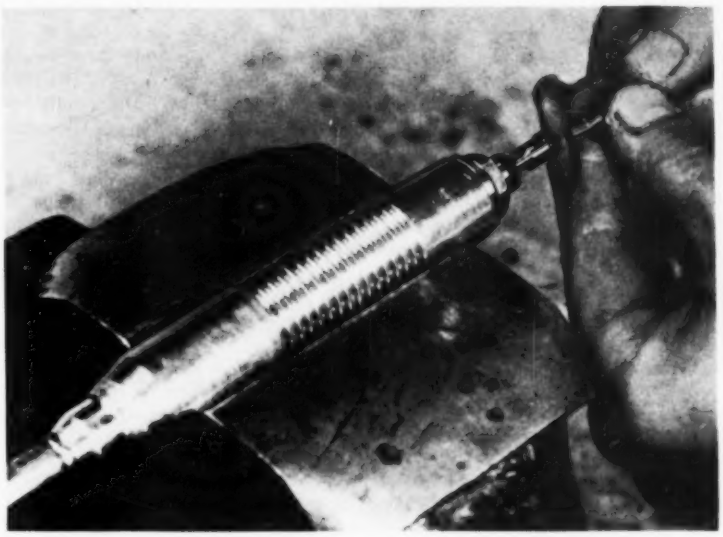


Fig. 2 — Solid Carbide Burs Like These Have Operated at Speeds as High as 33,600 R.p.m. Tool shown here is used to deburr automatic pencils

run. Lots ranged from 600,000 to 3,850,000 pieces of hardened steel, and from 380,000 to 2,050,000 pieces of soft steel. Comparison with similar runs using high speed steel rests showed a service life 30 times longer, on an average. Wear on the carbide portion of the rests after the 200 runs ranged between 0.005 and 0.009 in.

Although these carbide blades are more costly, the fewer regrinds required reduce blade cost to well below that of rests made of other materials.

Feed Pawls on Internal Grinders — Use of carbide feed pawls on internal grinders in one electric motor plant is expected to save around $3500 per year. Whereas standard steel feed pawls had to be replaced after every four or five days of operation, the original carbide pawls are still running after more than three years of constant use. After the first two plant departments showed a maintenance saving of $867 per year, the company decided to standardize on carbide feed pawls throughout the plant.

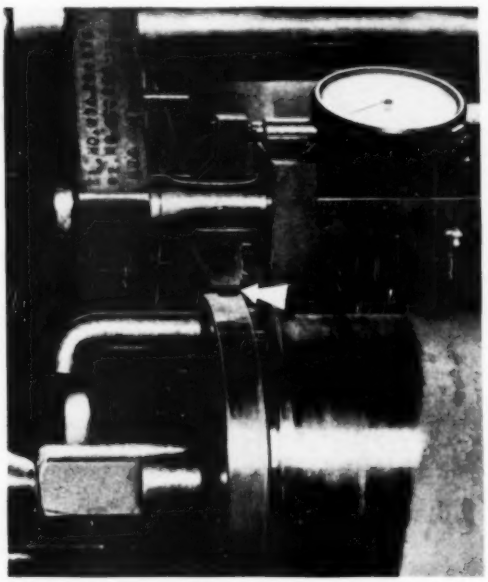


Fig. 3 — The Carbide Gage Finger Pointed Out in the Photograph Is Set so That When the Gage Reads "0" It Automatically Shuts Off the Machine Feed

Solid Carbide Grinding Tools — Grinding tools made of solid cemented carbide (Fig. 2) are finding wide application for the internal and jig grinding of small holes in soft and hardened steels (up to Rockwell C-65) and other metals. Such carbide burs are now generally available from several manufacturers of rotary files, but these grinding tools should not be confused with rotary files because the design and application are radically different. The working surface of the grinding tools is cut to produce many small sharp points. These small points cut like the grit particles in an ordinary grinding wheel, taking many minute chips. Used on a precision grinder, these carbide grinding tools produce more accurate work faster because: *(a)* The carbide doesn't break down like a grinding wheel, *(b)* more working pressure can be used because the solid carbide tool and shank are almost three times as stiff as the steel shank of conventional wheels, *(c)* carbide grinding tools don't flex and run out, *(d)* carbide grinding tools

can be run faster, and *(e)* they require less maintenance.

In one shop, average production with ordinary wheels on the internal grinding of hardened collets (Rockwell C-62 to 63) was between 10 and 20 units per wheel (sometimes as few as 2 or 3). Five minutes was required to grind each collet. Use of carbide grinding tools cut grinding time to 2 min. per unit; 218 collets were finished with one carbide bur before resharpening was required. Thus, downtime of equipment was also saved.

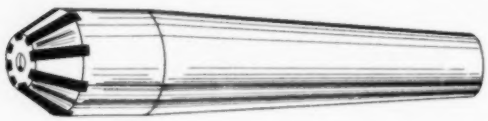


Fig. 4 — Bull Nose Grinder Centers

In another shop, it took five hours and six conventional grinding wheels to locate holes on a drill jig. The same job was performed in 17 min. with a carbide grinding point. Tolerance for locating was within 0.0002 in., an accuracy previously unobtainable.

For deburring and die sinking operations, solid carbide burs of conventional design are being used more and more extensively, replacing many small pencil wheels. Here again carbides are getting into the grinding field because they will hold size and shape longer and cut faster.

Carbide Gage Fingers on Grinders — Figure 3 shows another use on grinders — carbide gage fingers. The gage fingers contact the rotating work and are set so that when the gage reads "0" the machine feed is automatically shut off. It is, of course, impractical to employ steel for such purposes because steel wears away so rapidly that the operator would have to reset his gage continually to maintain accuracy of work.

Grinder Centers — Grinder centers tipped with carbide — like similar lathe centers — have been generally used now for a number of years with marked success. The smaller sizes are usually made with small cones of solid carbide set into steel shanks. The larger "bull nose" grinder centers, however — from 3½ to 4 in. diameter — are most frequently made by brazing carbide strips to the steel portion of the center, as in Fig. 4. Service life of carbide centers is usually measured in terms of *months*, rather than — as with conventional grinder centers — in *hours*. Chief reason for their longer life is their resistance to scoring and burning, even at continuous high speeds.

Grinding Wheel Dressers — Diamond-impregnated carbide grinding wheel dressers — now in current use in many shops for truing up wheels — represent a departure from the ordinary dresser in that they use a number of small diamonds rather than one large, expensive diamond. These small diamonds are held together in a matrix of hard carbide metal, as shown in Fig. 5. The design results in a lower cost dresser than when a large diamond is used. In addition, maintenance cost is lower since it is easy to re-expose new diamonds when others have worn. Faster and more accurate truing is also claimed. The carbide matrix holds the small diamonds so firmly — due to shrinkage during the sintering process — that "loosened" diamonds are eliminated.

As an illustration of the abuse which the carbide dresser can take without injury, ten passes were made with such a dresser into a 46N aluminum oxide wheel, each pass 0.100 in. deep. For a total depth of 1 in., it is claimed, the dresser showed no sign of harm. In normal operation, feeds of 0.005 to 0.010 in. are used.

Other Uses — Among other uses in the grinding field are carbide grinding quills, which have the

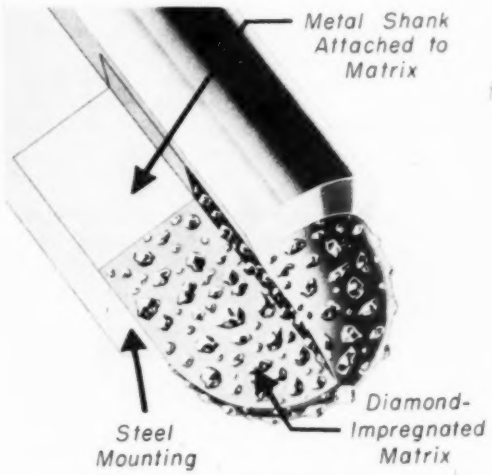
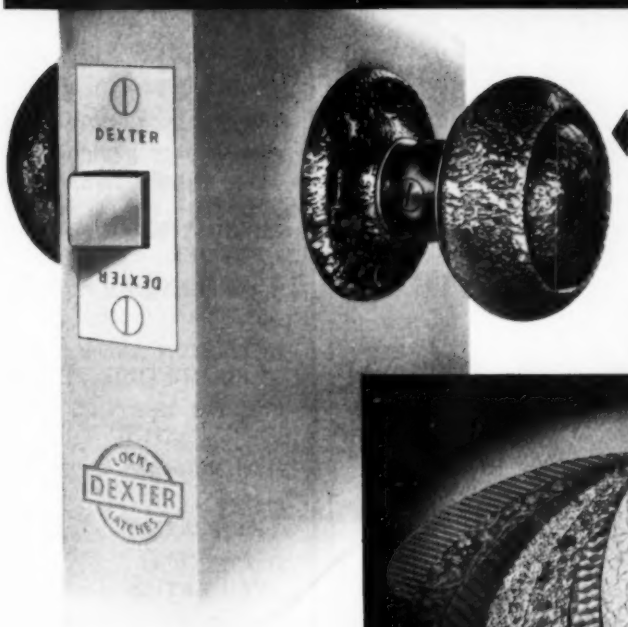


Fig. 5 — Diamond-Impregnated Carbide Grinding Wheel Dressers

advantage of nearly three times the stiffness of steel, thereby permitting increased loads for faster grinding. Carbide burnishing wheels are also coming into use. The successful application of carbide forming of abrasive wheels is reported, with a notable gain in service life over the steel wheels originally used. The electrical and automotive industries are finding many uses for carbides.

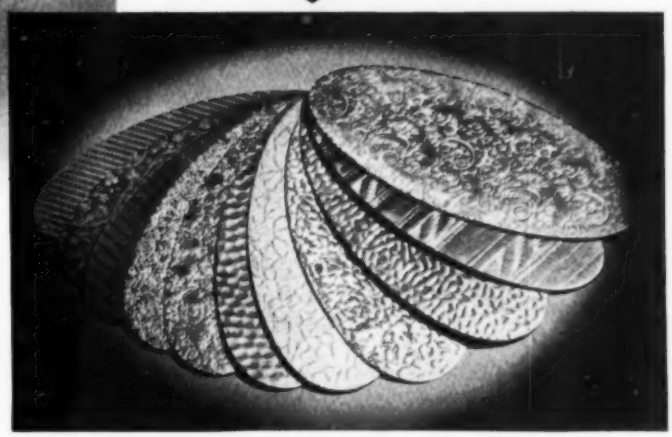
REVERE EMBOSSED METAL ADDS TO BEAUTY

of Solid Brass Hardware



A Dexter set made by National Brass Company, Grand Rapids, Michigan; in the lifetime beauty of solid brass. Knob is fabricated from a Revere Embossed Pattern.

Inset, some embossed patterns produced by Revere.



Quality hardware for homes and commercial buildings always is solid brass or bronze. There are no substitutes for these solid, ever-lasting metals that cannot rust, whose beauty is not skin deep but goes all the way through. Thus time and use improve the finish instead of spoiling it. That is why good buildings everywhere feature solid brass and bronze for such items as locksets, door knobs, butts, latches, hangers, hooks, and similar parts that should speak of quality as long as the building stands.

Take the National Brass Company. This well-known hardware manufacturer features solid brass 100%, knowing that any architect, builder or home owner recognizes the worth of enduring high quality. Their line is trademarked "Dexter", and one of its feature items is trim in etched finish. Actually these items use solid Revere Embossed Brass, which is furnished in a variety of standard and special patterns, ready for fabrication into articles of exceptional attractiveness, not only hardware, but also a wide range of products such as compacts, clock dials, cigarette cases, jewelry. National Brass states that Revere Embossed Brass not only produces a really handsome line, but one whose beauty increases with age, since use brightens the high-lighted raised surfaces, while the shadows in the depressions provide an effective contrast. Thus this fine Revere Metal assures lasting satisfaction to the home owner, and enhances the reputation of the architect, contractor, and builder. . . . For true quality, high sales appeal, and enduring service, wise manufacturers use solid durable metals such as copper, brass, bronze, nickel silver provided by Revere not only in Embossed Metal but in plain sheet and strip and in bar, rod, extruded shapes.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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* * *

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.

Sales Offices in Principal Cities, Distributors Everywhere.

Improved quality control of metals at **LOWER COST**

SPERRY ULTRASONIC REFLECTOSCOPE

Reflectoscope, Type UR, Style 50E351.

Provides rapid accurate non-destructive testing of steel and other metals

Metals tested by the Reflectoscope are preferred by users who cannot afford lost machine and man hours. The expense of lost work on faulty metals and possibility of service failures are minimized when potentially harmful defects are located before fabricating or machining.

The cost per test is low because it is instantaneous. The operator touches the quartz-crystal Searching Unit to the surface and immediately "sees" through the metal. Discontinuities are revealed on the Reflectoscope screen and are located accurately. For full details write for new Bulletin 50101.

- CONTROLLED SENSITIVITY —can be adjusted to meet quality control standards.
- PORTABLE UNIT — can be set-up quickly by one man.
- TESTS PARTS "IN PLACE" —locates fatigue cracks in shafts, rolls, axles and other stressed parts. Operates on 100-130 volt, 60 cycle current.

See the **REFLECTOSCOPE** at Booth 1920
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SPERRY PRODUCTS, INC.
DANBURY, CONN.

SPERRY

SP-1538

The series of 20 articles on

TITANIUM

which ran in recent issues of *Metal Progress* has now been reprinted as a 42-page pamphlet. These articles discuss:

- PRODUCTION OF POWDER
- CONSOLIDATION OF POWDER
- INDUCTION AND ARC MELTING
- VACUUM MELTING AND CASTING
- SPOT WELDING
- PHYSICAL PROPERTIES
- MECHANICAL PROPERTIES
- HIGH-TEMPERATURE PROPERTIES
- CORROSION RESISTANCE
- TITANIUM ALLOYS
- SELECTED BIBLIOGRAPHY OF 114 RECENT REFERENCES

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Nickel plated steel scissors stripped clean and bright without attack.

new Developments For Metal Finishing

METAL STRIPPER "A" – An alkaline chemical stripper for removing coatings of nickel, copper, zinc, cadmium and silver from steel *without any attack* upon the steel. Excellent for removing plated coatings as well as surplus metal from brazing or welding.

CLEANER S-61 – A new alkaline soak-type cleaner that is remarkably effective even at temperatures as low as 150°F. for removal of oil, grease, and buffing compounds from copper and steel.

EBONOL "S-30" – A new quick blackening process for iron and steel. Produces jet black coatings in five minutes.

INHIBITOR 9 – A new inhibitor for both hydrochloric and sulphuric acids for pickling of steel without attack. Saves acids. Also inhibits against hydrogen embrittlement.

NYLON ANODE BAGS – New nylon anode bags for nickel, copper, silver and other plating solutions. Made to specifications.

"SURPREP" – A new phosphating type cleaner for rapid removal of rust, oil and grease from large objects. Can be applied by brushing, wiping or spraying.

Write for New Bulletins on these Products

● *Fast action of SURPREP on oily steel.*

Enthone INC.
442 Elm Street, New Haven, Conn.

Personals

W. E. Mahin, chairman of metals research at Armour Research Foundation of Illinois Institute of Technology, Chicago, has been named director of research of the foundation.

Godfrey Tool & Supply, Inc., Cleveland, announces that **Joseph B. Clough** has been appointed vice-president. Dr. Clough was previously assistant to the president of the A. W. Hecker Co. and vice-president and sales manager of Johnston & Jennings Co.

Wm. G. Montgomery has transferred from the Geneva Steel Co. to the Tennessee Coal, Iron and Railroad Co. as plant metallurgist at the Fairfield, Ala., wire works.

Charles E. Thomas, formerly with the Lithium Co., is now with the chemical sales division of the Ethyl Corp., New York City.

Following graduation from the University of Notre Dame, **Robert L. Pobst** has accepted a position as metallurgist with Federal-Mogul Research and Development at Ann Arbor, Mich.

Utica Drop Forge & Tool Corp., Utica, N. Y., has appointed **Falih N. Darmara** to the post of director of metallurgy and research for the company. Dr. Darmara was formerly with the National Advisory Committee for Aeronautics and the research laboratory of the United States Steel Corp.

J. A. Durr, until recently technical adviser to the general manager of the Albion Malleable Iron Co., Albion, Mich., has joined the staff of the Erie Malleable Iron Co., Erie, Pa.

Richard H. Marshall, formerly production metallurgist of Timken Roller Bearing Co., has joined the metallurgical staff of the Climax Molybdenum Co., Chicago, Ill.

Homer C. Lackey has been appointed sales manager of the Chicago-St. Louis-Houston district for the Midvale Co., with headquarters in Chicago. Mr. Lackey has been with Midvale since 1930, most recently as district sales manager in Cleveland.

Service Associated, Inc., Chicago, announces that **C. W. Anderson**, formerly treasurer, is now president and treasurer and that **A. W. Anderson**, who was associated with Claud S. Gordon Co. for 34 years, is in charge of sales and engineering.

Universal-Cyclops Steel Corp., Bridgeville, Pa., announces that **W. J. Long** and **William G. Stewart** have been elected vice-presidents. Mr. Long has been with the company for about 20 years in various sales positions, serving as manager of toolsteel sales since 1945, and Mr. Stewart has been with the company for the same length of time, most recently as assistant secretary.

Amel R. Meyer, formerly welding engineer at Battelle Memorial Institute, is now welding engineer in research and development at Graver Tank & Mfg. Co., Inc., East Chicago, Ind.

John L. Bolles, a May 1949 graduate of Colorado School of Mines, is now employed by the Anaconda Copper Mining Co., Anaconda, Mont., as an assisting research engineer.

The Hyster Co., Portland, Oregon, announces that **J. F. Lewis**, formerly in charge of production and purchasing at the Peoria plant, is being transferred to Portland to assume the duties of chief production engineer in the company's three factories.

Arthur B. Wendt has recently accepted employment in the engineering department of the U. S. Graphite Co., Saginaw, Mich.

SIMPLE OPERATION

See it . . .
Metal Show
Booth 2645

NORMAL AUTOMATIC CYCLE

1. Work and tray on hearth in sealed heating chamber. Ipsen gas enters chamber at vestibule.
2. Tray is moved, by cold chain, onto quenching rack encased in a water jacketed chamber containing Ipsen gas.
3. Quenching rack is airdraulically lowered into an agitated oil bath. Oil surface is in direct contact with Ipsen gas.
4. Quenching rack is airdraulically raised into cooling chamber for removal.

THE AUTOMATIC Ipsen HEAT TREATING UNIT

WRITE FOR BULLETIN "T"

IPSEN INDUSTRIES, INC.

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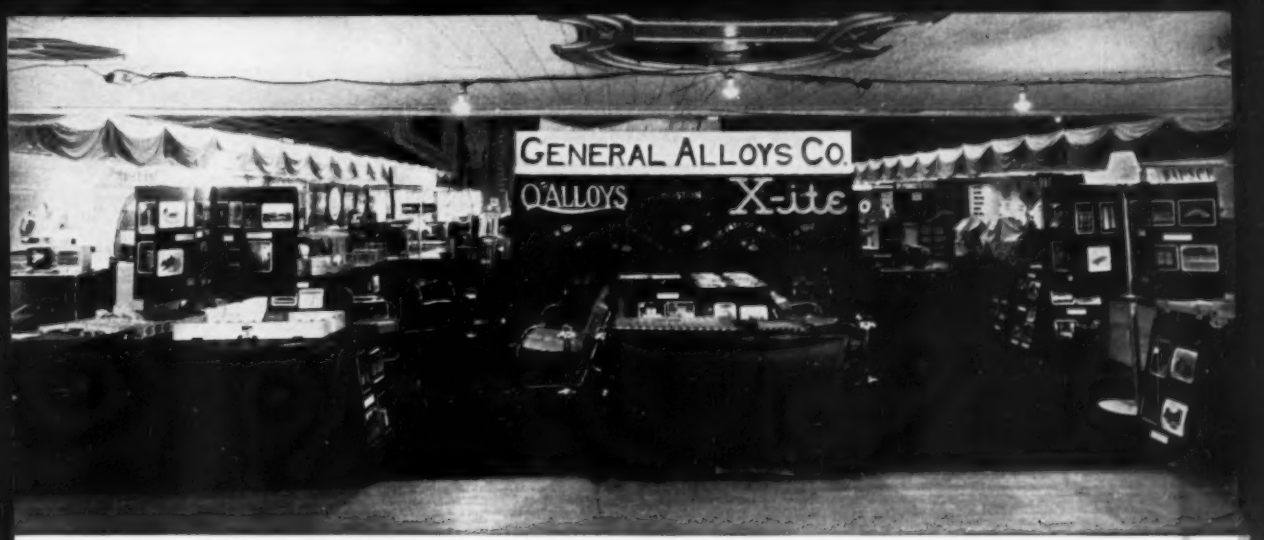


Old Friends, and New,

We'll See You in Cleveland!

IT'S OUR 31st CONSECUTIVE YEAR

as the largest, only continuous alloy casting exhibitor at A.S.M. Shows

As the years roll by, we've been meeting sons and daughters of many of our old friends. Recently, with the grandsons beginning to drop in at the Shows, time seems to be whizzing by.

Life has been good to us and the friendships which mature through the years add depth and fine human values to the stimulation of wrestling new problems and crossing once distant technical horizons.

For more than two years we've been "out of circulation", have called on no customers, missed all A.S.M. meetings and outings, — and really *missed* them. We've been working close to a 16-hour day and enjoying it. The work has been fruitful beyond our hopes, as a search for truth frequently is.

In June 1947, after several months of preparation, and nearly five years of specialized researches, I undertook the direction of what is believed to be the most thorough and best facilitated research and development program ever undertaken on casting fundamentals. Factors that control the structure, metallurgical integrity, cleanliness and physical properties of high alloy and alloy steel castings have, themselves, never been controlled. Those that were known have not been understood.

This Research and Development Project: — non-profit — was sponsored by the U.S. Navy with the Bureau of Ships and the Bureau of Aeronautics jointly participating and, because of space, special equipment and liaison with a great university, was principally carried on in Champaign, Ill., with supplementary work at Boston. Some General Alloys' personnel participated with Alloy Engineering and Casting Company staff and with a diversified group of Engineers, Metallurgists and Technicians assembled for the Project.

To facilitate this work, highly specialized and technically advanced equipment was designed and built on the Project to practical operating scale. Special laboratories were equipped with facilities never before assembled in a foundry. Precedents were ignored. Many related, and heretofore unrelated, arts, techniques, sciences and materials were explored and evaluated.

In more than thirty years' experience in design, metallurgy and the engineering application of casting techniques aimed at control of fatigue resistance and ultimate life of cast complex alloys, — in diverse forms for severe services, — we became *profoundly conscious of our ignorance.*

Having founded the World's first organization devoted exclusively to the engineering and casting of heat and corrosion resistant castings (and forging and rolling of these in specialized applications), we were guided by no printed art or technology. Nothing was taught in the technical skills about these materials. (Currently there is very little taught, most of which is dubious.) All our lives we have encountered obstacles, most of which evolved from "short-circuits" between human ears, were atrophied into "precedent" and were ultimately resolved by "common sense" uncommonly applied.

We thought many of our limitations were personal or organizational. Our war activities gave us a broad view of contemporary foundry activities from which we gleaned little, except on mechanized production. A few individuals, like the late Peter Blackwood, provided education and inspiration. Since, we have striven mightily to evaluate our non-exclusive ignorance. Much of this "knowin' wrong" began with a misconception of most casting fundamentals, obscured by the absence of controls, without which definite knowledge was unobtainable.

The urgent need in National Defense for jet and gas turbine engines, their actual potential expansion, and the coming implementation of Atomic Power, makes it imperative that:

(A) We advance our knowledge of designing, producing and employing heat and corrosion resisting materials.

(B) That these include Alloys, Ceramics, Cermets, Ceremels, Oxymets, Metalaminates, etc.

This new field has produced some little new technology. A stop-off exploitation of dental casting processes to the temporary exclusion of U.S. pre-war experience in high temperature materials and design is at last being metallurgically and mechanically rationalized. Some good work is emerging and a further shake-down is underway. More knowledge and less "experts" will emerge.

To date we have been too busy to seek commercial outlets to apply the broadly applicable findings of our Research and Development work. This work transcends the alloy casting field and will find many applications in the improvement of ferrous and non-ferrous castings, in structure, cleanliness and dimensional and surface precision heretofore unknown. Higher production at lower cost can result.

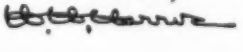
Such details of this Project as are "unclassified" will be released, subject to Navy approval, by the U.S. Technical Press, whose interest and cooperation have been most gratifying.

Eighteen editors and representatives of almost all Technical Publications covering this field, and more than fifty leading industrial concerns, have sent executives, engineers and metallurgists on Navy approved visits to the Project. Publication of details, as released with Navy approval, will appear in the Technical Press.

M. P. Readers have learned that grain size, in most as-cast materials, is almost directly proportional to fatigue life and has great effect on physical properties and corrosion resistance. You will be glad to know that casting grain size specifications (reducing the present range of "spread" by about 90%) can now be written for exacting requirements and will soon be common.

Some readers will appreciate the great satisfaction we have obtained in digging for, — and finding, — many answers to questions which have heretofore been unanswered. I regret the loss of my usual business contacts and visits with friends during the past two years, in compensation for which I can show but a minute reduction of a truly colossal ignorance.

To the Vision and Foresight which has guided Navy sponsorship of Research and Development Projects in Naval Laboratories, universities and in industry, can be credited many benefits to industry and the public, beyond the goals of technical excellence, economically applied, to Materiel for defense. Inspired by such Leadership and Support, we consider the past two years of our life have been usefully spent.



GENERAL ALLOYS COMPANY - Boston - U.S.A.

"Oldest and Largest Exclusive Manufacturers of Heat and Corrosion Resistant Castings"

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

Personals

Superior Steel Corp. announces that **Paul W. Pheneger** has been appointed assistant to the president. He has been with the operating division of the company since 1947, and prior to that was with the Michigan Seamless Tube Co.

Morton Parker has been transferred by E. F. Houghton & Co. from the Toledo, Ohio, division to the Pittsburgh sales division, where he will continue to act as a field representative.

O. M. Haseltine has been appointed sales engineer for the Ajax Electric Co. of Philadelphia. Mr. Haseltine, who was formerly with Service Associated, will maintain offices in Chicago.

David Edelstein, formerly assistant superintendent in charge of aluminum operations and later of scrap materials of the Perth Amboy plant of Federated Metals Division, American Smelting and Refining Co., has been named scrap purchasing agent for the eastern territory of the company. His office will be in New York City.

Following graduation from the New York State Institute of Applied Arts and Sciences, **Theodore F. Bishop** has been employed in the inspection department of the Dodge Brothers Corp., Detroit, Mich.

Emerson N. Ludington, formerly group test engineer (metallic) at Chance Vought Aircraft Co., is now chief metallurgist of the New Haven Clock & Watch Co., New Haven, Conn.

After graduating from Case Institute of Technology, **Robert J. Conklin** joined the metallurgical and inspection department of the Wisconsin Steel Works of International Harvester Co., South Chicago, Ill.

Francis L. Shubert, a recent graduate of the University of Minnesota, is now employed as a metallurgist with Combustion Engineering-Superheater, Inc.'s, East Chicago, Ind., plant.

Edward L. Pike, who graduated from Colorado School of Mines in May 1949, is now a junior metallurgist doing research in the Institute of Atomic Research at Iowa State College, Ames, Iowa.

James H. Bechtold, formerly instructor in metallurgical engineering at the University of Illinois, is currently employed as research metallurgist at Westinghouse Research Laboratories, East Pittsburgh, Pa.

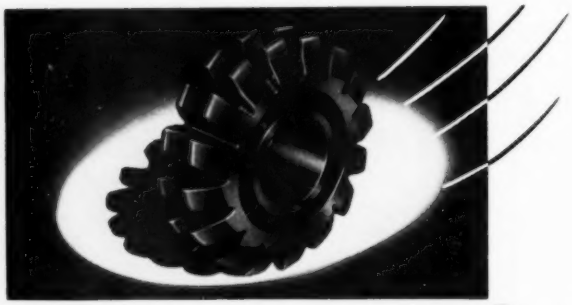
L. T. Martensen, who was formerly with the Lindberg Engineering Co. in Milwaukee, is now a sales representative in the Detroit district office of P. R. Mallory & Co., Inc., Indianapolis.

Casper J. Koeper has recently been transferred from the Rocket Branch, Office of Chief of Ordnance, to Redstone Arsenal, Huntsville, Ala., as chief of the design unit of the recently activated rocket laboratory.

C. T. Posey has been appointed field engineer in the Midwestern area for Arcos Corp., his headquarters being in Chicago. He will assist Arcos distributors, Machinery and Welder Corp. and C. E. Phillips & Co.

Howard Peters, formerly a vice-president of Mid-Continent Metal Products Co. of Chicago, is now project engineer for the rollpin division of Elastic Stop Nut Corp. of America, Union, N. J.

Henry Dahlquist, formerly a partner of Dahlquist & Brengle, announces the formation of the Henry Dahlquist Sales Co., Birmingham, Mich.

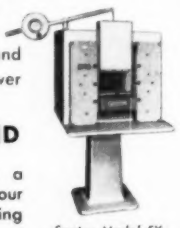


Reduce Tooling Costs
Increase Production

WITH **SENTRY** HARDENING

Full hardness and maximum toughness result when your high speed steel tools are hardened in Sentry Electric Furnaces using Sentry Diamond Blocks. Unusual contours and sharp corners are faithfully retained.

With Sentry Diamond Blocks a neutral atmosphere is maintained — no oxidation, no scaling, no reduction in size. Tools may be thoroughly soaked for maximum hardness without danger of burning. High resistance to breakage and longer tool life result in higher production and lower tooling costs.



Sentry Model SY Electric Furnace

SEE YOU AT THE
METAL SHOW—CLEVELAND
— OCTOBER 17 THRU 21 —
We'll be there — Booth 1131 — with a Furnace in actual operation. Bring your samples of HSS cutting tools for hardening demonstration.

Write for bulletin 1054—A15

The Sentry Company
FOXBORO. MASS., U.S.A.
Sentry DIAMOND Block

For better results in treating metals: Specify these long-lived Norton Refractories

tubes

Alundum Refractory tubes are made in a variety of sizes for electric furnaces of the metal resistor type. Because of the excellent electrical qualities of Alundum the resistor can be wound directly in the tube. They are used largely in furnaces for wire drawing, particularly tungsten and molybdenum and for sintering cemented carbides. Crystolon tubes can be supplied in the same sizes for many high temperature operations where electrical insulation is not a factor. Alundum is also available as thermocouple tubing and as pyrometer tubes, both ideal, for protecting costly thermocouples in temperature recording devices.

cores

Alundum cores are very useful in furnace manufacture. They have all the properties of Alundum tubes with the added physical feature of being molded with grooves for retaining the resistor wire. For the operator who must prepare a special furnace on the job, cores are a great help because the resistor can be applied easily and simply in the spacing provided.

The resistor may be spiralled or straight and wound in the grooves and then embedded in Alundum cement. Thus, fully protected, the wire is less liable to corrode since these mixtures are chemically inert. Alundum cores have high heat conductivity and do not become electrical conductors even at high temperatures.

muffles

One-piece muffles of both Alundum and Crystolon can be provided, rectangular, "D" shape and "U" shape for building small furnaces heated by oil, gas or electricity. Such furnaces are used in a great variety of operations and most prefabricated furnaces on the market have furnace chambers formed by muffles of one or the other of these materials. Only Crystolon muffles are carried in stock, but Alundum muffles are gladly supplied on order. Alundum muffles are used primarily where electrical resistance is desired at temperatures above 1250° C. In electric furnaces the resistance wire encircling the muffle should be embedded in Alundum cement.

small furnace refractories

mixture designation	composition	structure	shapes available	remarks
RA 98*	alumina 89%	fine	cores, tubes, muffles and most special shapes	subject to reduction of silica above 1450° C. in reducing atmosphere.
RA 1139*	alumina 99%	fine	cores, tubes, muffles and many special shapes	used to 1650° C. but subject to distortion above 1350° C. under load.
RA 1192*	alumina 99–%	fine	tubes and certain flat and simple shapes	used to 1750° C. but subject to some distortion above 1600° C. under load.
RA 1213	alumina 99–%	medium	tubes, certain cores, muffles, and flat and simple shapes	used to 1900° C., little distortion in use to 1800° C.
RA 1191	alumina 99–%	coarse	tubes, certain muffles and flat shapes	used to 1900° C., little distortion to 1850° C.; coarse grained surface.
RC 217*	silicon carbide 65%	fine	cores, tubes, muffles and special shapes	reduction, oxidation and electrical conductivity increase with temperature; not recommended for use above 1100° C.; suitable for use with base metal resistors only.
RC 1138	silicon carbide 83%	medium fine	some cores, tubes, muffles and special shapes	reduction, oxidation and electrical conductivity increase with temperature; not recommended for use above 1450° C.; suitable for use with base metal resistors only.

*suitable electrically heated furnaces only.

refractory cements

In the construction of externally wound electric furnaces, tubes and muffles are covered with a cement to hold the resistor in place and to protect it from contamination by materials which might damage it. Norton cement mixtures are composed of Alundum grain, suitably sized, to which is added a ceramic binder. Norton refractory cements used for imbedding resistor elements are purposely designed to reduce possible reaction to the minimum.

Can't be beat for handling heat!

Norton Company • Worcester 6, Mass.

NORTON REFRACTORIES

Personals

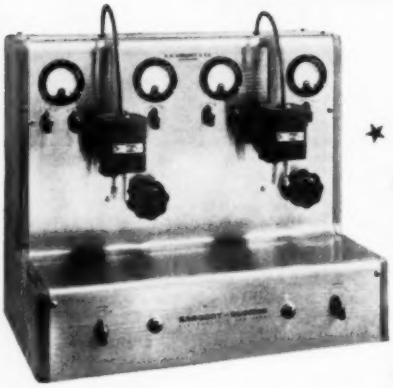
Brown Instruments Div. of Minneapolis-Honeywell Regulator Co. announces the appointment of **Charles D. McIntire** as industrial sales manager of the Cincinnati branch office and **William C. Waltman**, formerly with the Syracuse, N. Y., office of Brown, in charge of industrial sales of the South Bend, Ind., office.

Universal Sheet and Strip Steel Co., Chicago, announces the appointment of **Joseph M. Williams, Jr.,** as vice-president in charge of strip steel operations. Mr. Williams was with Acme Steel Co. since 1922.

After many years as metallurgist for the Standard Tool Co., Cleveland, **Norman Deunk** is now at the National Twist Drill and Tool Co., Rochester, Mich., in the metallurgical department.

SARGENT-SLOMIN

Electrolytic Analyzers



★ **Immediate shipment from stock**

FOR HIGH SPEED QUANTITATIVE ANALYSIS OF

Ferrous and non-ferrous metals and alloys.
Electroplating solutions and electrodeposits.
Ores and minerals.
Metals in biological materials.
Metals in foods, soils, etc.
Forensic materials.
Micro and semi-micro specimens.

Designed for continuous trouble-free performance

No speed change with change of load.

All parts of the new electrode chucks are made of stainless steel. A simplified design utilizes a positive retaining spring which permits quick, easy insertion of the electrodes and maintains proper electrical contact.

These new analyzers used with the specially designed high efficiency corrugated electrodes rapidly produce smooth, close grained deposits at maximum current density.

The new Sargent-Slomin Electrolytic Analyzers represent a complete re-design of the original Slomin instruments. Each unit is mounted within a case consisting of a one-piece stainless steel panel, beaker platform and apron with sturdy end castings. All models are completely self-contained and operate from 50-60 cycle electric circuits—no auxiliary generators or rheostats are required.

The two position analyzers consist of two complete, independently operating analyzer circuits. Duplicate or check analyses can be run at the same time or two different analyses can be run simultaneously at different current densities.

The central electrode is rotated by a new capacitor type induction motor, operating at 550 r.p.m., especially engineered for this application. Under development for five years, this motor has been thoroughly tested and approved for continuous operation. Fully enclosed for protection against corrosive fumes—the shaft, sleeve bearings, and cap are made of stainless steel.

Outstanding features of this rugged motor are:

Greater output than any motor of similar characteristics and size.

No internal switches or brushes.

No "permanent" magnets—full output for long service life.

S-29460 ELECTROLYTIC ANALYZER — Sargent-Slomin, One Position, with Heating Plate. For operation from 115 Volt, 50-60 cycle circuits **$250.00**

S-29465 ELECTROLYTIC ANALYZER — Sargent-Slomin, Two Position, with Heating Plate. For operation from 115 Volt, 50-60 cycle circuits **$395.00**

S-29632 ANODE — Platinum gauze, Corrugated Form, High Speed. (Patent pending.) Price subject to market.

S-29672 CATHODE—Platinum gauze, Corrugated Form, High Speed. (Patent pending.) Price subject to market.

SARGENT

SCIENTIFIC LABORATORY EQUIPMENT AND CHEMICALS

E. H. SARGENT & COMPANY, 155-165 EAST SUPERIOR ST., CHICAGO 11, ILL.

MICHIGAN DIVISION 1959 EAST JEFFERSON DETROIT 7, MICHIGAN

SOUTHWESTERN DIVISION 5913 PEELER ST. DALLAS 9, TEXAS

Edgar C. Bain, vice-president in charge of research and technology of Carnegie-Illinois Steel Corp. and former president of the American Society for Metals, has been awarded the John Price Wetherill Medal of the Franklin Institute, Philadelphia.

Vernon H. Patterson, formerly sales metallurgist of American Brake Shoe Co., has joined the development staff of the Climax Molybdenum Co., Detroit, Mich.

U. S. Reduction Co., East Chicago, Ind., announces that **J. B. Neiman** has been added to its staff as an executive assisting in both the purchasing department and in the sale of aluminum alloys. Mr. Neiman, who was formerly general manager of the aluminum department of the Federated Metals Div., American Smelting & Refining Co., will operate from Detroit.

George Perrault, Jr., formerly sales and advertising manager of the Salem Engineering Co., has been appointed sales manager of the rolling mill division of E. W. Bliss Co. at Salem, Ohio.

Edward S. Steigner, a member of the Youngstown Sheet and Tube Co.'s metallurgical department for 15 years, has been appointed tubular products development engineer, with his office in the Campbell, Ohio, works.

Roy Erwin Swift, formerly on the faculty of the school of chemical and metallurgical engineering of Purdue University and a recent recipient of a doctor's degree from Yale University, has joined the faculty of the Mackay School of Mines of the University of Nevada, Reno, to teach mining and metallurgy.

Geo. H. Thurston has left the American Smelting and Refining Co.'s Selby, Calif., plant and is now metallurgist at Hall-Scott Motor Division, ACF-Brill, Berkeley, Calif.

Industrial Heating Equipment Co., Detroit, announces the appointment of **George C. McCormick** to the position of sales manager and of **Clifton E. Wenger** to that of controlled atmosphere engineer. Mr. McCormick was formerly associated with General Alloys, Sterling Alloys and Loftus Engineering Corp., while Mr. Wenger had worked for Buick Motor Div., Detroit Transmission Div. and most recently the Dow Furnace Co.

H. O. Klinke has been appointed assistant manager of the apparatus research division of Air Reduction Sales Co., Murray Hill, N. J.

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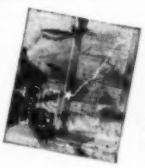

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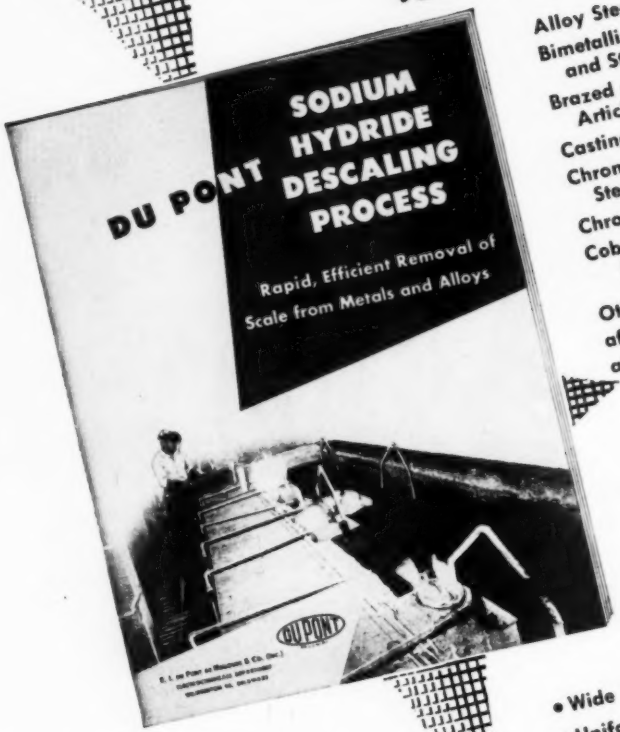

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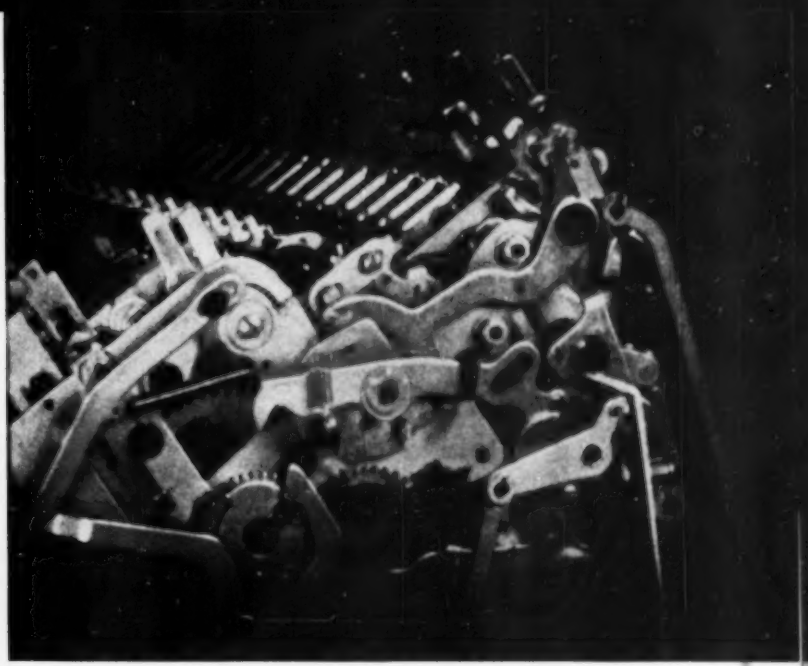

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Weldability of C-Mn Steels*

THE DEVELOPMENT of a laboratory test method for quantitatively evaluating the weldability of steels has been the primary objective of many welding investigations undertaken during and since the second World War. These studies have pursued various aspects of the problem, but the work reviewed by Voldrich and Harder is concerned primarily with structural carbon-manganese steels (0.17 to 0.33% C and 0.40 to 1.62% Mn) and their response to welding, with particular reference to underbead hardening, bead-bend ductility, and underbead crack sensitivity. The data discussed were obtained from studies carried on at Battelle Memorial Institute for the Welding Research Council, from 1941 to 1948.

In the underbead hardening studies, a Class E6010 electrode, ⅛-in. diameter, was used in depositing weld beads on 6x12-in. pieces of steel plates ¼, ½, 1 and 2 in. thick. Weld beads ½ and 3 in. long were deposited at a travel speed of 5 in. per min. with 180 amp. at 26 arc-volts (direct current, electrode positive). Beads were sectioned transversely at midlength and a Vickers hardness survey made of the cross section using a 10-kg. load to locate maximum hardness in the heat-affected zone.

The data indicate that a good relationship exists between the carbon and manganese contents of the steels and maximum hardness in the heat-affected zone of the weld. "Carbon equivalent", as given by the expression C + Mn/6, was used in this study. Using limiting maximum hardness criteria of 350 Vickers for freedom from underbead cracking and 250 Vickers for satisfactory service performance in the as-welded condition, the approximate limiting carbon equivalents are as follows (applicable without preheating):

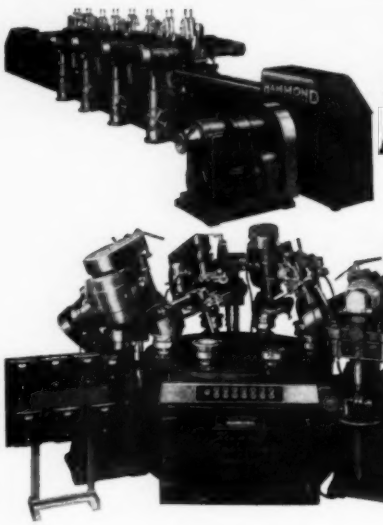
Vickers Limit	Plate Thickness, In.			
	¼	½	1	2
350	0.60	0.50	0.45	0.40
250	0.45	0.40	0.35	0.30

Fine grained steels show a somewhat higher maximum hardness than coarse grained steels, and cast steels exhibit higher maximum hardness in the heat-affected zone than wrought steels of corresponding composition. The greatest increase of maximum hardness due to plate thickness occurred either between ¼ and ½ in. or between ½ and 1 in. with relatively little increase between the 1 and 2-in. thicknesses. This is taken to indicate that a maximum cooling rate is reached at the 1-in. thickness.

The studies of bead-bend ductility were initially conducted using weld bead specimens similar to those described for the underbead hardness studies. The tests were made on specimens in the ½-in. plate welded at an initial plate temperature of 80° F. only. Ductility was evaluated by measurements of angle of bend, maximum load and elongation on the tension face of the specimen. The results of these initial tests were inconclusive, although the cast steels exhibited considerably less capacity for bending than the wrought steels. Some of the weld bead specimens with high hardness in the heat-affected zone exhibited considerable ductility and bent to the capacity of the bending jig without cracking. This behavior is not explained.

(Continued on page 540)

*Abstracted from "Review on the Weldability of Carbon-Manganese Steels", by C. B. Voldrich and O. E. Harder, *Welding Journal*, July 1949, p. 326-s to 336-s.



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Weldability of C-Mn Steels

(Starts on page 538)

Further preliminary studies of bead-bend ductility were made using test specimens cut transverse to the weld bead with a notch on the bead centerline extending to a depth of $\frac{1}{8}$ in. below the plate surface. The tests were made at room temperature and measurements were made of bend angle, maximum load and type of fracture. These test specimens were taken from a 6x12-in. plate on which a weld bead about 5½ in. long had been deposited along the short centerline of the piece.

It was found that either a square notch with rounded corners or a U-notch with a full root radius would function satisfactorily, although the fracture type appeared to be more consistent with the U-notch and so this notch was selected for the remainder of the work. From these pilot tests it appeared that depth of notch is not a critical factor so long as the notch is not cut entirely through the depth of the weld bead into the heat-affected zone. A constant notch depth of $\frac{1}{8}$ in. below the plate surface with a $\frac{1}{8}$-in. root radius was used for the later work.

Since the results of bend tests are influenced by section modulus of the test specimen as well as the metallurgical properties of the heat-affected zone in welded specimens in different plate thicknesses, it was indicated that isolation of the effect of cooling rate on bend properties could be obtained only by fixing the section modulus of the test specimen. This condition may be accomplished by either one of two procedures: All bend test specimens can be machined to the same thickness after welding is completed, or the welding may be done on a single plate thickness with the effect of plate mass being produced by artificial means of cooling.

It was also found that bend properties of welded specimens may change appreciably with time. An aging period of one week at room temperature or 16 hr. at 212° F. produced a substantial increase in the bend angle of specimens welded with E6010 electrodes. Longer periods produced no further improvement. This improvement in bend properties by short-time aging may be associated with the release of hydrogen from the weld metal and heat-affected zone.

In the main program of notch-bend studies, plate thicknesses of ½, ¾ and 1 in. were used and all plate specimens were welded with an initial plate temperature of 80° F. Electrodes of E6010, E6020, E6012 and E6015 classes were used in $\frac{1}{8}$-in. diameter, with uniform welding current and arc voltage, but welding speeds were varied with each electrode to obtain welding heat inputs of 30,000, 50,000 and 70,000 joules per in. After welding, the plates were aged for 20 hr. at 200° F., after which test specimens 1½ in. wide were machined transverse to the weld bead. A U-notch with $\frac{1}{8}$-in. root radius and depth $\frac{1}{8}$ in. below the plate surface was cut along the centerline of the weld bead and all specimens were bent on a 9-in. span at room temperature. For comparison with these welded specimens similarly notched unwelded plate specimens were also tested.

The results of these notch-bend tests may be summarized thus:

1. Bend angle decreases as carbon and manganese contents increase and plate thickness in-

(Continued on page 542)

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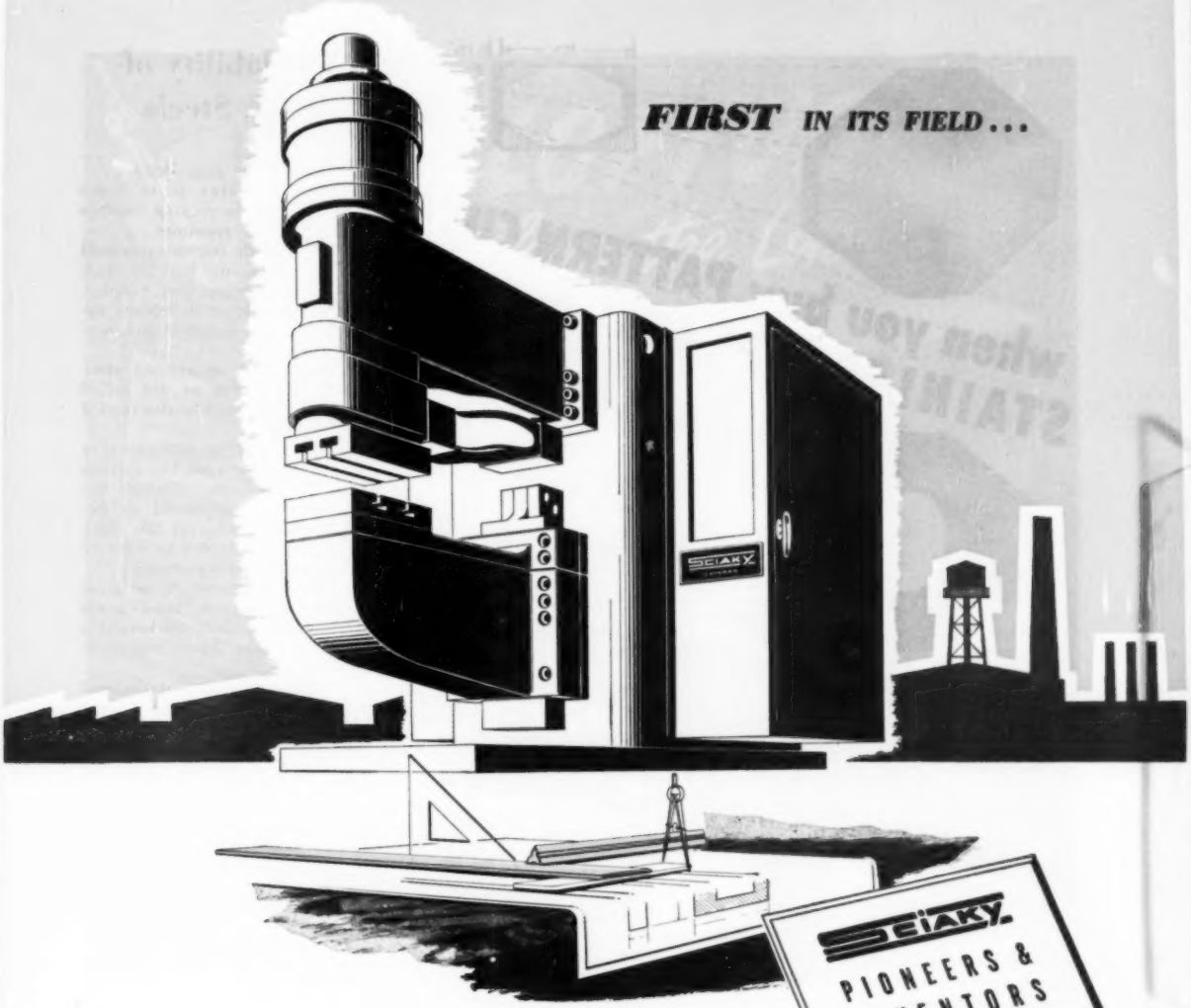

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Weldability of C-Mn Steels

(Starts on page 538)

creases. The latter is to some extent due to increasing section modulus of test specimen.

2. Bend angle increases as heat input is increased. For the 1-in. plate little increase was noted.

3. No significant difference appeared between as-rolled and normalized plate.

4. Cast steels responded similarly to heat input as did rolled steels, although bend angles tended to be smaller.

5. There was no difference in bend response between the various classes of electrode, although the E6015 electrode produced no underbead cracks, whereas the other classes of electrode did in some of the higher chemistry steels.

6. There appeared to be good correlation between bend angle and maximum underbead hardness with similar heat inputs and cooling rates.

Observations of underbead cracking in the heat-affected zones of all the hardness and notch-bend specimens indicate that this cracking tendency increased as carbon and manganese contents and weld cooling rates increased, except that no underbead cracking occurred when the E6015 electrode (low hydrogen, mineral-type coating) was used. To study this tendency more accurately, a series of crack-sensitivity tests was conducted.

The test specimen used for this study consisted of a 1-in. weld bead deposited along the long axis of a steel block 1 in. thick by 1½ in. wide and 4 in. long. The bead was deposited using an ⅛-in. electrode with 100 amp. and 26 arc-volts at a travel speed of 10 in. per min. Each specimen was stress relieved and sectioned longitudinally on the centerline of the weld bead. The total length of underbead cracks was measured so that the percentage of cracking could be determined. Electrodes of classes E6010, E6020 and E6015 were used and tests were made with three initial plate temperatures: room temperature, 150 and 225° F.

The results indicate that crack sensitivity increases as carbon and manganese contents increase. This tendency decreases as the initial plate temperature is increased. Using carbon equivalent as C + Mn/4 + Si/4, it is indicated that

(Continued on page 544)

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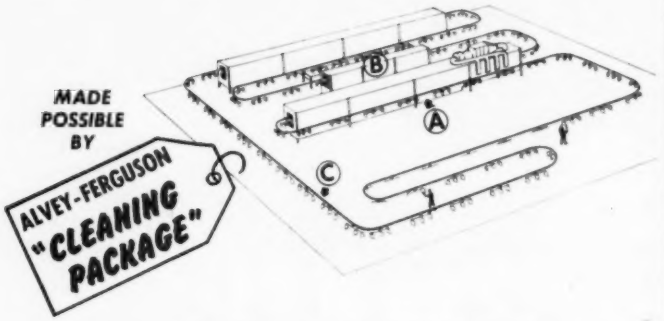

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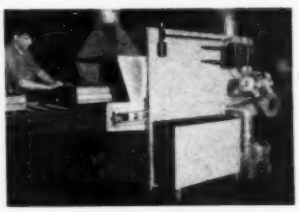

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Weldability of C-Mn Steels

(Starts on page 538)

for the same carbon equivalent the cast steels showed much less underbead cracking than the rolled steels. The reason for this occurrence is not explained.

It is pointed out by the authors that the crack-sensitivity data permit a relative comparison of the test steels, but as yet there is no firmly established criterion for the maximum permissible cracking, in the welding test used, which will predict the behavior of the steel in production welding. What is needed are more complete crack-sensitivity data for different plate thicknesses and preheats, and data on the actual cooling rates for the crack-sensitivity tests.

These test data suggest a need for information concerning the relationship between maximum underbead hardness, bend angle ductility and underbead crack sensitivity with reference to base metal composition when welded under identical conditions, that is, with similar cooling rates. Also, the tests were all made at room temperature so that data are not available on performance at subzero or elevated temperatures. The authors further point out that the data on cooling rates are insufficient to make possible their application to predictions of the behavior of a steel under specific production welding conditions.

Fatigue of Metals*

THE two well-known books in English on the fatigue of metals, one by H. G. Gough and the other by H. F. Moore and J. B. Kommers, are now more than 20 years old and do not include recent developments of the subject. Fortunately, a most substantial book on fatigue was published in 1937 by two French engineers, R. Cazaud and L. Persoz, and the first of the two authors continued to work on the volume after his collaborator died. Now we have the third edition of that important work.

In the person of R. Cazaud, France has a technical writer of

(Continued on page 546)

*Review of "La Fatigue des Metaux", Third Edition, by R. Cazaud, Dunod, Paris, 318 p.

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Fatigue of Metals

(Starts on page 544)

great erudition, enormous personal experience, deep and critical insight, and a capacity for brevity, clarity and fluency in writing. The book should be translated into English but since that is unlikely, it would be desirable for English-speaking metallurgists and engineers to study it in the original. It is an excellent book, too, for the reader to use for improving his knowledge of the French language.

The first chapter of the book is quite short. It introduces the reader to the history and the literature of the subject.

The second chapter abounds in illustrations of fatigue failures and fissures. No doubt the engineer should become thoroughly acquainted with the manner in which fatigue failures develop, and there is no other way but to study the "fractography" of failure (to borrow Zapffe's excellent term) in order to obtain a clear picture. Fortunately, the publishers of Cazaud's book did not economize in the quality of the paper or of the engravings used in this third edition; all illustrations are clear and to the point. The second chapter contains also brief but lucid descriptions of the different methods used to detect fissures and imperfections.

In the third chapter Cazaud presents all the theories offered to explain the mechanism of failure in general and of fatigue especially. The brevity of presentation of Rankine's, Saint Venant's and Coulomb's theories shows how little Cazaud must think of them. He pays more attention to Schenk's and Chevenard's methods of studying the hysteresis curves in the post-elastic range and this is exactly what should be done in experimental studies. Chevenard's method applied to microsamples is extremely neat, as is everything coming from that scientist.

The fourth chapter deals with the experimental methods of studying fatigue. It describes briefly but clearly fourteen different machines used for simple fatigue tests, and six installations for studies of the combined effects of static loading plus fatigue and of fatigue in torsion superimposed on fatigue in bending. There is, however, one minor point of criticism that might be raised here. When, as in Table II of this chapter, the fatigue limit in torsion is given as 13 and in bending as 14 kg. per sq.mm., to describe their ratio as 0.929 stretches

(Continued on page 550)

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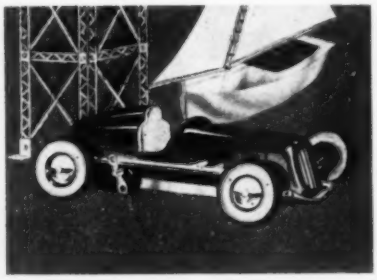
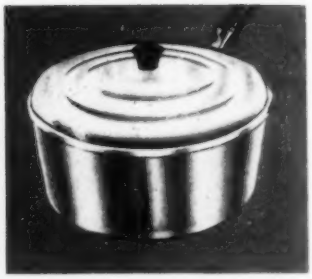
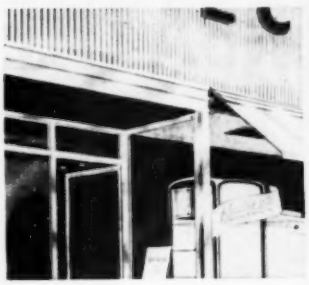
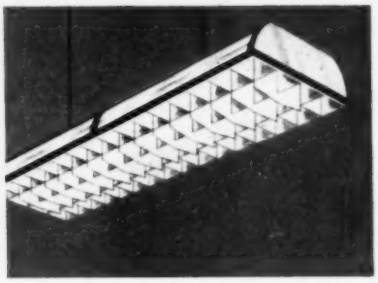
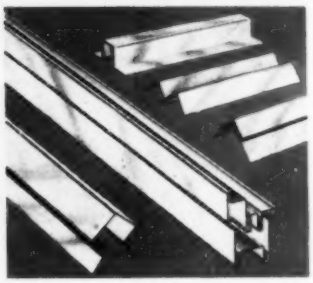










No other alloy can be fabricated in so many ways to do so many jobs—because no other alloy so effectively combines ALL *these advantages:*

GOOD PHYSICAL PROPERTIES. Yield strength and workability have been established to make it suitable for the widest variety of applications.

GOOD WORKABILITY. Most single, double and triple stage drawing can be done. With proper equipment spinning can be done satisfactorily. Beading formed by dies in a press can be handled well. Roll forming, brake forming, and lock seaming can be accomplished easily.

VERY FINE GRAIN STRUCTURE. Its chemical composition makes Kaiser Aluminum 150S inherently a fine grain alloy, uniform in all tempers.

EXCEPTIONAL FINISHING PROPERTIES. Satin anodized finishes, with a silvery white color, fine texture and consistent uniformity, can be obtained. Many finishing operations can be eliminated. And the hard surface resists scratches.

GOOD WELDING AND BRAZING PROPERTIES. Heliarc welding, spot welding and brazing can be done.

EXCELLENT CORROSION RESISTANCE. 150S has salt corrosion resistance properties comparable to 52S.

ARE YOU NOW USING 3S?

Here are definite advantages you get with 150S:

- 30 to 40 per cent greater strength in finished parts.
- Very nearly the same workability you now get with 3S.
- Harder, more scratch-resistant surface.
- Uniform, finer grain texture in all tempers.
- Fast, high lustre buffing.
- Superior etch finishes—clear, white, uniform.
- Anodized finishes superior in color to 3S.
- Up to 10 per cent less material cost where extra strength allows gauge reduction—only slightly higher cost for equal gauges.
- Corrosion resistance, welding and brazing properties equal to or better than 3S.

ARE YOU NOW USING 52S?

These advantages will be yours with 150S:

- Superior workability.
- Decided cost advantage if you're using 52S overstrength.
- No Lueder lines or strain markings in shallow draws.
- Finishing characteristics, corrosion resistance, welding and brazing properties equal to or better than 52S.

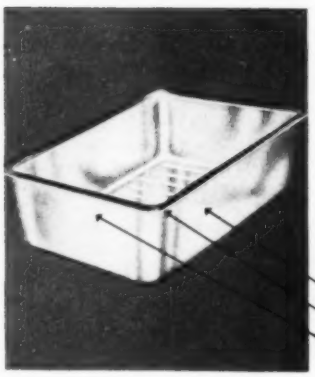
Kaiser Aluminum Alloy 150S may offer you sufficient strength at low cost to make conversion to aluminum from other materials *permanent* and *profitable*.

VERSATILE ALUMINUM ALLOY

TYPICAL TENSILE PROPERTIES OF VARIOUS 150S TEMPERS

Here are typical figures for thicknesses of about .040" to .051". Elongations are slightly lower for thinner sheet, slightly higher for thicker sheet.

Temper	Tensile strength	Yield strength	Elongation % in 2"
150S O	21,000 p.s.i.	8,500 p.s.i.	25%
150S H 22	23,500 p.s.i.	16,500 p.s.i.	13%
150S H 32	25,500 p.s.i.	21,000 p.s.i.	9%
150S H 34	28,000 p.s.i.	24,500 p.s.i.	6%
150S H 36	30,000 p.s.i.	27,000 p.s.i.	5%
150S H 38	32,000 p.s.i.	29,000 p.s.i.	5%
150S H 18	33,000 p.s.i.	31,000 p.s.i.	4%
150S H 19	37,000 p.s.i.	35,000 p.s.i.	3%



But that's not the whole story of the greater strength of 150S! Here are typical yield strengths of 150S compared with 3S:

Yield strength, p.s.i.				% increase with 150S
3S O:	7,000	150S O:	8,500	21.5%
3S H 12:	17,000	150S H 32:	21,000	23.5%

When drawn parts of the two alloys are compared, the difference in strength is even greater! Here, for example, is a comparison of drawn parts of a refrigerator crisper pan:

Test location	Yield strength, p.s.i. 3S	150S	% increase with 150S
Side	19,200	26,100	35.9%
Flange	17,700	24,500	38.4%
End	16,400	22,300	36.0%

GET THESE COMPETITIVE ADVANTAGES WITH 150S: If you are now using 3S, 52S, copper, brass, steel, or other materials, you may be able to cut manufacturing and equipment costs—and improve your product and fabrication techniques—with Kaiser Aluminum 150S! Today—call or write the nearest Permanente Products' sales office for more information on the world's most versatile aluminum alloy—150S!

See production samples of Kaiser Aluminum Alloy 150S at the *Annual National Metal Congress and Exposition—Cleveland, October 17–21.*

Permanente Metals

PRODUCER OF

Kaiser Aluminum

SOLD BY PERMANENTE PRODUCTS COMPANY, KAISER BLDG., OAKLAND 12, CALIFORNIA . . . WITH OFFICES IN:
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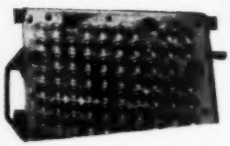
EXPORT OFFICE, OAKLAND, CALIFORNIA • WAREHOUSE DISTRIBUTORS IN PRINCIPAL CITIES

THESE 3 SPEED STEELS ARE "money in your pocket"

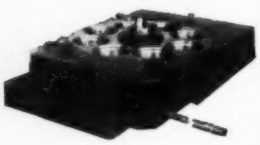
SPEED CASE

A free machining, low carbon, open hearth steel plate, stocked in thicknesses ¼" to 8". Tensile strength 58-72,000 p.s.i. At cutting speeds of 150-250 s.f.p.m. tool life averages 5 to 15 times that of other open hearth steels. It is easily carburized to achieve high surface hardness, and can be forged, cold formed, or welded, using proper techniques. Ideal for molds, dies, plates, fixtures, sprockets, etc.



80 cavity male Speed Case rubber mold. Machining costs lowered 41%.

SPEED TREAT

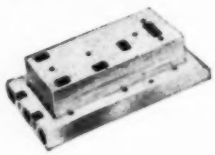


8 station ratchet dial feed, for "cupping" press, of Speed Treat.

A free machining, medium carbon, open hearth steel plate, stocked in thicknesses ¼" to 8". Tensile strength as rolled 90,000 to 105,000 p.s.i. Average cutting speeds of 135-145 s.f.p.m. produce an excellent finish, reducing polishing time and increasing tool life. It can be direct quenched - carburized and hardened, or induction or flame hardened. Can be forged and welded using proper techniques. Ideal for molds, dies, plates, rollers, gears, crane buckets, power shovel dippers, baling press housings, etc.

SPEED ALLOY

A free machining, hot rolled, alloy steel plate, stocked in widths up to 72", thickness up to 6". High physical properties. Bridges the gap between carbon and tool steels. Has deep hardening properties gained by the addition of chromium and molybdenum. Recommended where relatively high compressive strengths are required. Ideal for extra quality rubber molds, press brake dies, die sets, cold trimming and forming dies, cams, eccentrics, platens, racks, pressure rings, slides, ways, yokes, zinc die cast dies, etc.



Carburized and hardened Speed Alloy mold, with hobbed cavities, made by W & L Molding Co., Kalamazoo, Mich. Note mirror finish.

SINCE 1856

W. J. HOLLIDAY & CO. (INC.)

SPEED STEEL PLATE DIV.

137th & Sheffield Ave., Hammond, Indiana

Plants: Hammond and Indianapolis, Indiana

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Fatigue of Metals

(Starts on page 544)

precision a bit too far. The ratio could be 0.90 as well as 0.95. It is worth mentioning that the concluding paragraph of the fourth chapter relates to the tests of crankshafts for fatigue, using special machines of ±300 tons capacity. Such full-scale testing of large parts is, of course, done in the U. S. too. This is very interesting testing, capable of bringing balance to the general tendency of recent years to resort to nondestructive methods.

The fifth chapter covers the results of fatigue tests and does it in a profusion of diagrams and tables. The fact that Cazaud is well versed in metallography helps him to coordinate mechanical characteristics with structures. The chapter is most instructive for persons of a critical trend of mind. The diagrams show, for instance, how few in number were the data on which the endurance curves were traced by various experimenters. Too often, investigators have drawn such curves far above the points plotted in the diagrams. And the formulas on p. 124 to 129 show how pitiful were various efforts to form some simple equation connecting the fatigue limit with the tensile or yield strength. On the other hand, Cazaud shows that the ratios of the fatigue limits to the characteristics mentioned narrow down considerably if the *structures* are given due consideration.

The sixth chapter (very brief) and the seventh (quite substantial) examine the effects of dimensions and frequency of the cyclic loading and the character of the surface.

In the eighth chapter are collected data on the influence of temperature, chemical corrosion and chemical stabilization (protective atmospheres and coatings). The question is posed regarding the existence of a true fatigue limit in corrosion, and it seems that Cazaud is very doubtful concerning the existence of such a limit.

The ninth chapter examines the fatigue of parts obtained by riveting and welding, and the tenth chapter considers various methods for improving the fatigue limit. Like other chapters, these two are provided with numerous tables and very neat and clear diagrams.

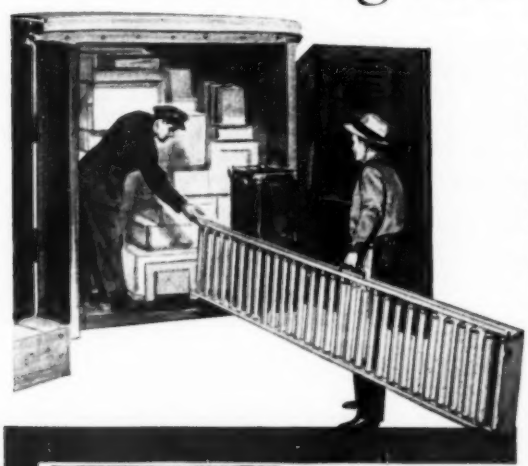
Bibliography? Chapter by chapter, the book contains the following numbers of references: 29, 46, 48, 41, 35, 37, 39, 57, 35, 81.

M. G. Corson

Cutting dead weight pays dividends — increases output and lowers cost. You can save more weight with Dow

MAGNESIUM

the world's lightest structural metal!

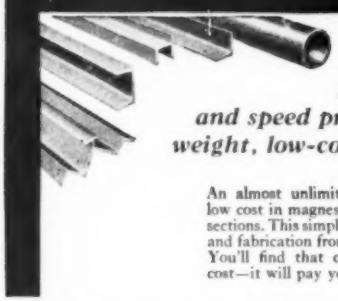


The users of all types of industrial equipment are more and more appreciating the dollars and cents value of *lightness*. That's why there is a growing demand among these people for equipment made of magnesium. They know that only with magnesium can they obtain the ultimate in combined light weight, strength and rigidity.

Magnesium is the lightest structural metal you can buy. It's 33⅓% lighter than aluminum and just ¼ the weight of steel. Yet for all its lightness, magnesium is a remarkably strong and usable material.

Magnesium is versatile, too. It is available in extrusions, die castings, forgings, sand and permanent mold castings, as well as sheet, plate, and strip. It is readily and easily fabricated by conventional shop procedures.

To see how leading designers in many fields are making magnesium pay dividends in increased efficiency and lower costs, write for your free copy of "How Magnesium Pays". It can pay you, too.



Simplify design and speed production with light weight, low-cost Magnesium Extrusions

An almost unlimited *variety of shapes* can be extruded at low cost in magnesium. Thus designers can use more efficient sections. This simplifies shop procedures because costly forming and fabrication from standard shapes and sheets is eliminated. You'll find that on many counts—versatility, workability, cost—it will pay you to use magnesium extrusions.

Lighter Products Sell—make your product Magnesium Light!

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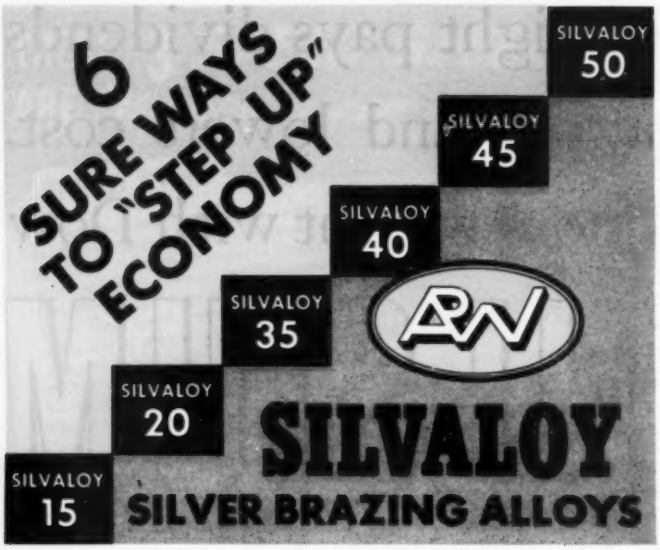

This year's National Metal Exposition has taken as its theme "Economy in Production". In line with this, low temperature silver brazing is frequently the economical answer to many assembly problems.

SILVALOY, the silver brazing standard in industry, may be able to do your job more economically. SILVALOY 15 is a silver-copper-phosphorous alloy, in nation-wide use, for brazing copper and copper alloys. The five other SILVALOY alloys are quaternary silver-copper-zinc-cadmium alloys which meet industry's demand for better, more practical, silver brazing.

SILVALOY means better quality, better results

ALLOY NO.	SILVER CONTENT	MELTING POINT	FLOW POINT
SILVALOY 15	15%	1185°F	1280°F
SILVALOY 20	20%	1430°F	1500°F
SILVALOY 35	35%	1125°F	1295°F
SILVALOY 40	40%	1135°F	1205°F
SILVALOY 45	45%	1125°F	1145°F
SILVALOY 50	50%	1160°F	1175°F

ALSO, A WIDE VARIETY OF OTHER SILVER SOLDERS FOR SPECIAL APPLICATIONS

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Properties of Mg-Zn Compounds*

THE published data on the constitution and properties of magnesium-zinc alloys are contradictory and a new determination was needed. The previous difficulties were caused largely by the necessity of working with cast alloys in the compositions involving intermetallic compounds. As a result of the discovery of the plasticity of intermetallic compounds under pressure at high temperatures (see abstract in *Metal Progress* for July, p. 126), it was possible to study both cast and worked alloys in this work.

The reason that the structure and properties of alloys depend on their previous thermal and mechanical history is the small diffusion velocity and the consequent slow approach to equilibrium. The degree of equilibrium determines the appearance of the constitution diagram of the solidified alloys, the course of the curve of property versus composition and the quantitative value of the property. The cast specimens used in this work showed coarse two-phase and non-equilibrium three-phase structures. The curve of Brinell hardness versus composition obtained for these alloys in the range from 70 to 100% Zn was characterized by a spread in experimental points and the absence of special points corresponding to the compositions of the intermetallic compounds.

Although annealing permits an alloy to approach equilibrium, annealing the cast alloys for 20 days failed to produce the equilibrium single-phase structure. However, by first working the alloys by extruding or pressing at high temperature and then annealing for 20 days, a satisfactorily equilibrated condition was produced. Microscopic study showed that the structure was refined and new grain boundaries produced. Three single-phase regions were determined corresponding to the intermetallic compounds MgZn, $MgZn_2$, and $MgZn_5$, and their solid solutions. A curve of hardness versus composition determined at 20° C. revealed minimums at the compositions cor-

(Continued on page 554)

*Abstracted from "The Phase Diagram and Mechanical Properties of the Magnesium-Zinc System", by E. M. Savitskii and V. V. Baron, *Doklady Adak. Nauk S.S.S.R.*, Vol. 64, 1949, p. 693-696. (In Russian.)

Bulletin on SUPER REFRACTORIES

by CARBORUNDUM
TRADE MARK

NO. 5 OCTOBER, 1949

EXTRA ADVANTAGES REALIZED WITH SUPER REFRACTORIES

Super refractories are often applied to meet a definite objective. While accomplishing this primary purpose, other benefits are also realized that may well provide economies or production advantages of even greater value than the original objective. For example, in a particular installation, a certain super refractory or combination of super refractories may be selected to secure greater production. While this goal is achieved, reduced maintenance through longer life of the refractories, lower fuel consumption and other secondary benefits can easily add up to savings that assume greater importance than the primary objective.

Generally speaking, the advantages realized from properly selected and applied super refractories by CARBORUNDUM may be grouped as:

- Longer service life.
- Fewer outages for repair and replacement.
- Increased production.
- Better quality ware.
- Fewer rejects.
- Lower fuel consumption.
- Less maintenance.

Results, such as these, are possible because of the unique characteristics of these products. In the chart shown here, these characteristics are tabulated.

Physical Properties of Super Refractories by CARBORUNDUM
TRADE MARK

	CARBOFRAX	MULLFRAX	MULLFRAX S	ALFRAX K	ALFRAX B	ALFRAX BI
Heat Conductivity at 2300°F. in BTU/hr. sq. ft. and °F./in. of thickness	109 BTU	16 BTU	9 BTU	24 BTU	12 BTU	7 BTU
REFRACTORINESS PCE CONE	37-40	38-39	37-38	37-39	39-40	38-39
SPALLING RESISTANCE	High	High	High	Good	Good	Good
ABRASION RESISTANCE	High	Medium	Medium	High	Medium	Low
THERMAL EXPANSION (25°—1400° C.)	.0000044	.0000059	.0000069	.0000074	.0000086	.0000086
MODULUS OF RUPTURE @ 2462° F. PSI	800-3125	100-250	175-475	100-1050	100-225	50-100
WEIGHT 9 IN. STRAIGHT	9.25 lbs.	9 lbs.	8 lbs.	10.1 lbs.	7.25 lbs.	4.8 lbs.

Switched to CARBOFRAX hearth for longer service . . . realized important production cost cuts

A CARBOFRAX silicon carbide hearth was installed at this metal working plant. At work temperatures ranging from 1200° to 1850° F. and under loads as high as 600 lbs. per pan, other hearth materials proved unsatisfactory.

With the switch to a CARBOFRAX hearth, service of 3½ years is not unusual. In addition, four times as much work is turned out. Oil consumption has been cut. Time is saved. Maintenance and repairs are minimized. The overall savings in production costs that are realized from the secondary benefits have paid this operator dividends over and above his original expectations.

Foundry specifies CARBOFRAX linings to lower maintenance costs . . . gains extra benefits

In this case, CARBOFRAX linings were installed in 14 coke-fired, crucible type melting furnaces for the specific purpose of lowering maintenance costs per pound of aluminum bronze melted. Extended experience revealed that this primary objective was achieved . . . plus . . . additional important benefits accruing from distinctive characteristics of these linings. Uniquely resistant to high temperatures, cracking and erosion, original lining dimensions are retained even after extended service. This hard, dense lining prevents clinker adherence and subsequent penetration to eliminate cutting-back or "bellying" on removal of clinker formations. Cleaning is facilitated. Coke consumption is held to a minimum. Made accurately to size, CARBOFRAX blocks are installed quickly.

"Carborundum," "Carbofrax," "Mullfrax," "Silfrax," "Alfrax" are registered trademarks which indicate manufacture by The Carborundum Company

Address all correspondence to: Dept. J-109, THE CARBORUNDUM COMPANY, Refractories Division, Perth Amboy, New Jersey

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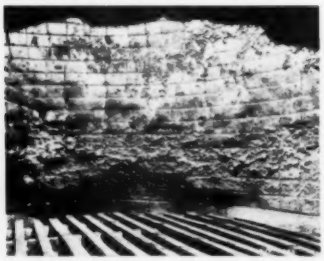
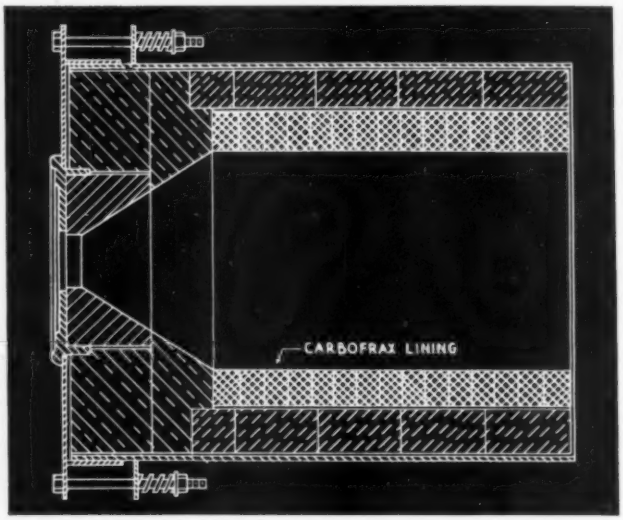


Investments to obtain increased Gas Make pays extra dividends

Seeking increased gas make, this operator installed a CARBOFRAX lining in a water gas generator. Thru its use, the full grate area is available longer. Clinkers build-up more slowly on the hard, smooth lining. A more active, uniform fire is obtained. As clinker accumulations are removed in about half the time previously required, down-time is reduced. The hotter set enables a faster resumption of gas production. The dirty, disagreeable clinkering job is made easier by the absence of embedded clinker formations. Moreover, lining service is now 5 times that secured with clay linings.



CARBOFRAX ignition chamber lining proves ideal for rotary driers

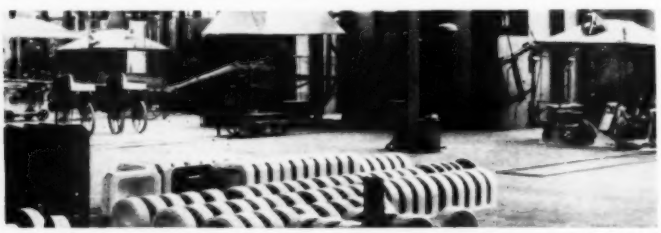
In low temperature rotary driers, oil deposition on the charge is a serious problem often encountered. It usually is caused by huge volumes of incoming air chilling a portion of the projected flame before combustion is completed.

Attempting to correct this condition, an ignition chamber was lined with "CARBOFRAX" brick. Far better fuel vaporization resulted from the hot radiant face of the "CARBOFRAX" lining—all fuel was burned within the combustion chamber. Not only did this solve the carbon problem. The smoke nuisance also was eliminated.

Subsequent installations on driers handling a variety of materials including dolomite, limestone, kaolin clay, etc., confirmed initial experience. On several rock drier jobs fuel consumption dropped from 1½—2 gallons to ½ gallon of oil per ton of rock dried. Moreover, "CARBOFRAX" linings have given at least a year's life compared with 2 to 3 weeks from other type of refractories.

Ceramist gains longer life from Kiln Furniture plus additional advantages

By using CARBOFRAX slabs and setters, this kiln operator increased service life of the shapes to an average of more than 465 trips. Shapes remain straight and true. There is no growth nor cracking due to thermal shock. Necessary rebuilds are cut considerably. And the uniform quality tile guards against premature failure of a few pieces that often account for costly kiln wrecks.



Enameler sought increased production—got it with extra economies

By installing CARBOFRAX muffles and supports in his furnaces, this manufacturer of cast iron sanitary ware stepped up production because of the high thermal conductivity of this material. At the same time, fuel consumption was cut, a more uniform temperature throughout burning chambers is maintained, and a longer muffle life and an increase in the life of the furnaces are realized. These improvements are due to the superior characteristics of CARBOFRAX muffles.

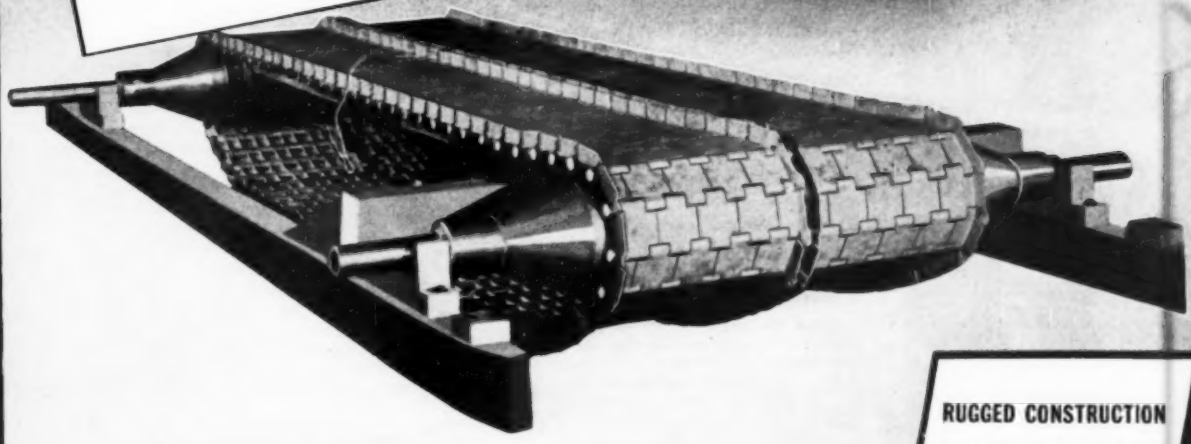
A complete file of informative literature covering super refractories is available through The Carborundum Company. There are facts and figures on installations in specific fields. To obtain copies of reports, booklets and catalogs of particular interest is a simple matter. Merely select from the list printed here. Copies will be sent you at once. No obligation, of course.

- Super Refractories by CARBORUNDUM (general catalog)
- Super Refractories for the Ceramic Industry
- Super Refractories for the Process Industry
- Super Refractories for Boiler Furnaces
- Super Refractories for Heat Treatment Furnaces
- Super Refractories for Gas Generators
- The FRAX Line of Cements
- CARBOFRAX Refractory Skid Rails
- Bulletins Nos. 1, 2, 3 on Underdrain Systems and Diffuser Media

Dept. No. J-109

THE CARBORUNDUM COMPANY
Refractories Division
PERTH AMBOY, NEW JERSEY

Belt Conveyors For Industrial Furnaces



RUGGED CONSTRUCTION
CARRIES HEAVY LOADS
LONG SPANS
POSITIVE CLEARING
SIMPLE REPLACEMENT
Low Cost

A Standard Alloy Belt Conveyor in your hardening or annealing furnace will pay for itself in trouble-free, efficient operation. There are no "weak links" in a Standard Alloy Belt Conveyor. Generous wall thicknesses provide more than sufficient strength to withstand even the most extreme requirements.

Most installations are entirely enclosed in the heating chamber of the furnace, permitting the work to be deposited on the intake end and discharged directly into a quench tank or other medium at the discharge end, and since the belt wholly operates within the furnace, a negligible amount of heat is lost.

6 REASONS WHY STANDARD CONVEYOR BELTS *ARE BETTER!*

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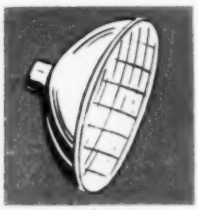
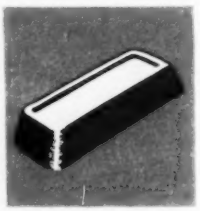


Sealed-beam Headlights
— coated by vacuum evaporation
— vacuum-exhausted

Blood Plasma
— vacuum-dried



Titanium
— melted and poured in vacuum furnaces

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KINNEY
HIGH VACUUM PUMPS

Properties of Mg-Zn Compounds

(Starts on page 552)

responding to these three intermetallic compounds.

The compound $MgZn_2$ is congruently melting and therefore has a higher melting point than neighboring compositions. In order to exhibit clearly the hardness minimum corresponding to this compound it was necessary to determine hardness values at relative temperatures — namely, 75% of the absolute temperature of melting of each composition.

The influence of temperature on the Brinell hardness was determined by testing the worked and annealed alloys at 325° C. Although the room temperature hardness of the alloys in the region of the intermetallic compounds (70 to 100% Zn) was of the order of 300 kg. per sq.mm., the hardness at 325° C. was only 30 to 50 kg. per sq.mm. Alloys consisting of a mixture of intermetallic compounds decreased most rapidly in hardness with increase in temperature. Alloys containing eutectic showed a smaller decrease, and the pure intermetallic compounds were most resistant to softening.

Rapid Method for Phosphorus in Steel*

A REPORT has been released by the Ford Motor Co., disclosing a spectrographic method that permits routine determinations of phosphorus in steel. To date, some 7000 heats have been analyzed effectively. An operator can make a single determination in 2 min., or 30 per hr. The speed of analysis permits effective control of phosphorus, as heats of steel can be held in the furnace long enough to determine whether they are too high in phosphorus. Dilution with low-phosphorus material to reduce the phosphorus content to meet specifications is thus practicable.

With ordinary spectrographic methods, the determination of certain critical elements, such as carbon, sulphur and phosphorus, usually

(Continued on page 556)

*Abstracted from "A Geiger-Müller Counter Method of Determining Phosphorus in Steels", by F. A. Bryan and G. A. Nahstoll, *A.S.T.M. Bulletin*, March 1949, p. 55-61.

ON HEAT TREAT APPLICATIONS . . .

3 out of 4 pyrometers are calibrated for CHROMEL-ALUMEL thermocouples

According to recent estimates made by leading instrument manufacturers, 75% or more of the pyrometers now in use on heat treating applications are calibrated for CHROMEL-ALUMEL thermocouples. There are reasons for this almost universal acceptance and use. Good reasons, too. For CHROMEL-ALUMEL couples give you more accurate temperature readings over longer periods of time than any other known base metal materials. They're unconditionally guaranteed to register true temperature—E.M.F. values within $\pm 5°$ between 32° and 660° F., and within $\pm \frac{3}{4}\%$ at temperatures over 660° F. Extremely durable, too. So resistant to oxidation that you need not pack the protection tube. Highly responsive to temperature fluctuations!

So, if accurate temperature measurement is important to the finished quality of your work, better make sure your meters are calibrated for and equipped with CHROMEL-ALUMEL couples. And it's a good idea, too, to complete your chain of accuracy with CHROMEL-ALUMEL *extension* leads. They belong together!

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at 1800° F.
In the demonstration, a tube of this distinctive material, basically Titanium Carbide, simulates a Resistance Heating Element. It is subjected to alternate electric heating and air cooling in one-minute cycles, while under constant tensile stress of 10,000 p.s.i. Temperature range 1800° to 180° F
Also featured in the display is a Thermocouple Protection Tube made of Kennametal, which, by means of a high frequency induction coil, is maintained at a temperature of 2600° F.
The Grade K138 series includes several different compositions, each having a specific combination of properties that meet some particular operating condition at elevated temperatures.
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SUPERIOR CEMENTED CARBIDES
KENNAMETAL DISPLAY
Booth 520
IN THE ARENA

Rapid Method for Phosphorus in Steel

(Starts on page 554)

present in small amounts, is extremely difficult. In the new method, advantage is taken of the demonstration by O. S. Duffendock and W. E. Morris at the University of Michigan, in 1942, that ultraviolet light of wave length below 2600 Å can be used to actuate Geiger-Müller photoelectron counter tubes. In the new spectrometer, these tubes are used to replace the photographic plate. The essential equipment consists of an electrical arc source, a large Littrow quartz spectrograph and the Geiger-Müller counter attachment with its associated electrical circuits. No dark room is required since data used for the calculations are read directly from meters. The complete spectrograph is thermostated to increase the accuracy. The small, nonself-quenching photoelectron G-M tubes are of unique construction, being comprised of a cylindrical nickel alloy cathode and a fine tungsten wire anode supported within a fused quartz envelope filled with pure hydrogen at 10 cm. pressure. Due to the light-absorbing and photoelectron-emitting characteristics of the various component parts, these tubes are usable only between 1800 and 2600 Å. They are very stable; such tubes have been in service for more than two years with no noticeable change in sensitivity.

To achieve an accuracy within 5% of the phosphorus present, the operation of the equipment requires meticulous adjustment. Molten metal to be analyzed is poured into molybdenum molds to produce rod-shaped electrodes that must be held to close dimensional tolerances. These are provided with conical points to produce a steady arc, and when placed in the arc holder, must be spaced very accurately.

In the laboratory development, a 2200-volt a-c. arc of 2 amp. was satisfactory, but for safer operation in plant use, a 220-volt d-c. arc has been employed. Of the several phosphorus and iron lines available, the phosphorus line at 2136.19 Å is most usable because of its high arc intensity and relative freedom from interference; the iron reference line selected is one at 2219.9 Å, chosen primarily because its intensity is nearly equivalent to that of the phosphorus line. The light of these two frequencies from the steel sam-

(Continued on page 558)

ANOTHER DIE CAST PRODUCT MADE BETTER ON KUX DIE CASTING EQUIPMENT

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speedier and more economically

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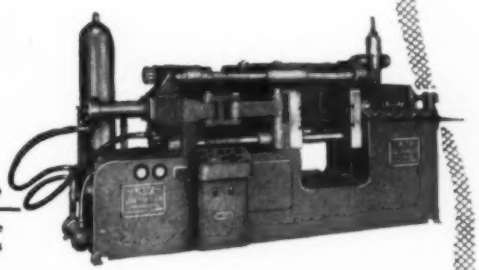

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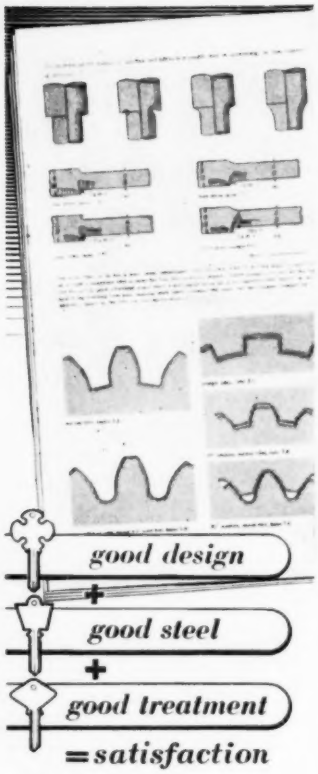

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Rapid Method for Phosphorus in Steel

(Starts on page 554)

ple being analyzed is focused by the spectrometer on two G-M counters and the ratio of intensities is measured. With most steels, during 1 min. of arcing sufficient phosphorus "counts" are produced to provide acceptable accuracy. The exposure is terminated when 100 iron "counts" have been recorded.

Experimental data obtained on typical steels, both with the laboratory experimental model employing the 2200-volt a-c. arc and the production model using a 220-volt d-c. arc, covering a range from 0.007 to 0.021% P, have been compared with standard chemical analyses with gratifying results. From 346 determinations, average deviations from the mean were found to range from 0.001 to 0.004% P. Average deviations in routine chemical analysis extend from 0.002 to 0.008% P, the greater deviations occurring among samples of higher phosphorus content. In test analyses of electric furnace crankshaft steels, the average deviation from the chemical analysis has been reduced to 0.002%.

Transition Temperatures*

IN a program of testing four quenched and tempered low-alloy high-yield strength (66,000 to 84,000 psi.) constructional steels for determination of transition temperatures by means of tension tests, the authors have used three different forms of specimens. Two of them are simple flat-plate notched tension specimens and the third is a rather complex "restrained welded" tension specimen consisting of steel plates set along three mutually perpendicular planes and welded together to form a "hatch-corner" configuration. This form of specimen was found to produce a stress distribution, in the main plate strength member under load, equivalent to that found in the deck member of the "hatch-corner" specimen used in a previous investigation *(Weld-*

(Continued on page 562)

*Abstracted from "Transition Temperatures of Structural Steels", by A. Boodberg and E. R. Parker, *Welding Research Supplement*, April 1949, p. 167-s to 177-s.

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ELECTRIC HEATERS
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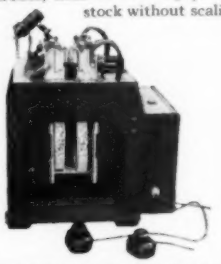

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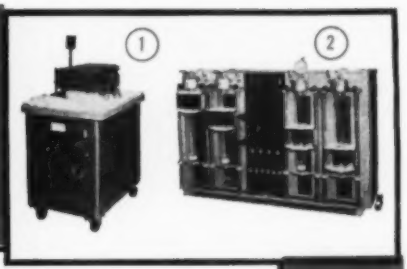

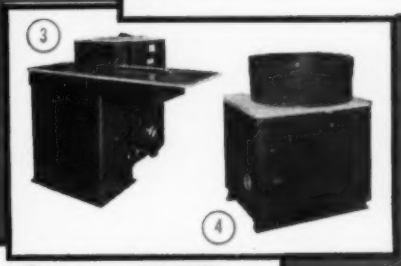

1. Ecco Model M40 60-cycle induction-type ring gear expansion heater with automatic heat control and pneumatic release.

2. 4-position high vacuum degassing furnace, complete with sliding induction heater coils and pumps.

3. Ecco spark converter and conveyor-type induction soldering machine.

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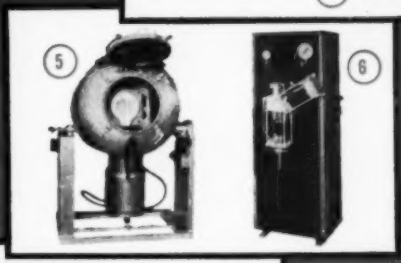

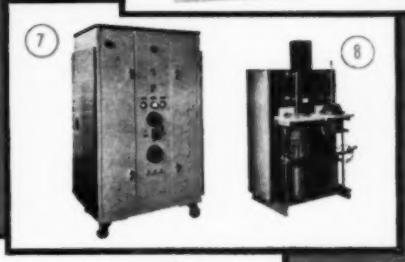

VACUUM MELTING

5. Ecco Model F58, 50 to 100 lb. high frequency vacuum melting furnace with motorized tilt and mold chamber. Stationary drum, swinging crucible units, arranged to pour into several molds and with means to add alloying specimens can be supplied in capacities ranging from 30 to 300 lbs. Complete vacuum pumping and gauging equipment included.

6. Ecco Model F85, 2 to 10 lb. vacuum melt, pour and pressure furnace with provisions for preheating the mold.

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9. Ecco 35-KVA spark converter, with high frequency power distribution and 4 induction melting furnaces.

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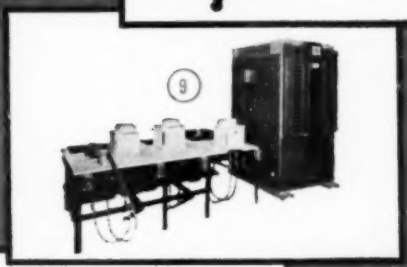

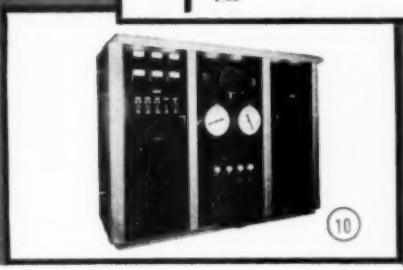

10. Ecco high frequency motor generator and controls. From 20 to 1200 KW, 1200 to 10,000 cycles and melting capacity from 5 lbs. to several tons.

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What's new, we ask, about trying to cut costs? Everybody's been trying for years. Now, with high labor costs, high raw materials and overhead, we still seek "economy in production."

Metal manufacturers have already screened every operation. They've installed mass production machinery; they've investigated substitute materials, better materials handling. But perhaps here is one angle some plants haven't yet considered. We refer to the processing materials used to form, machine and heat-treat metal parts. Let's get specific:

Houghton supplies the metal industry with some 500 products, grouped into such general classes as heat-treating salts, carburizers, quenching oils, cutting fluids, drawing compounds, lubricants, rust preventives and cleaners.

These products are not sold on low first cost, but on their over-all efficiency, plus a personalized service which helps plants use them most effectively. We call that experience, gained over three generations of metal-working. Houghton's "Know-How." We offer it to metal men who are earnestly seeking new angles to cut costs and meet competition.

Instances of how Houghton products and "Know-How" have reduced costs for others are set forth on the opposite page. Please read them and consider how such examples might apply to your business. Then put it up to the Houghton Man, or write us direct.

For "know-how" know Houghton

(HOW TON)

FACTS FROM THE FIELD

Reports show how Houghton "know-how" saves time — saves money

A sure way to cut costs without spending huge sums for new equipment is to examine the processing materials used to shape, form and heat-treat metal parts. Houghton makes and services such materials. Its success over the years has been based on ability to reduce production costs and solve perplexing problems for metal men. Below are authenticated case studies, briefed for quick reading. One or more may touch your own procedures:

DRAWING — A farm machinery manufacturer was punching and coining bars from ½" hot-rolled plate. Using white lead in oil as a drawing lubricant cost them $52.98 a day. They tried *Houghto-Draw*, mixed with mineral oil and then with water. Punches were brushed with the mixture every four operations as against each operation previously. Result: daily cost with Houghto-Draw, $4.38; saving: $48.60 per day.

CLEANING — A bolt manufacturer had the tough job of removing asphaltic-type rust preventive from surplus stock so it need not be scrapped. *Houghto-Clean 220*, an emulsion cleaner, was suggested, diluted 1 to 5 with water. It worked, where steam and alkaline cleaners had failed. In barrel-type washers the same product used in 4% solution lasts several weeks, with small weekly make-up. Former method required daily additions, increasing cost of cleaning.

CUTTING FLUIDS — An automotive parts maker changed its cutting oil used in an automatic on SAE 1045 bar stock, from a straight oil costing 49¢ per gallon, to Houghton's *Antisep All-Purpose Base*, mixed 1 to 15 with water. This dilution has been used 8 months both as cutting fluid and machine lubricant. Cost of cutting oil alone, for 40 working days: $52.80 for Antisep against $404.50 for straight oil. No lubricating oil required. Tool life improved . . . no sign of bearing wear or corrosion . . . parts handled bare-handed . . . no dermatitis complaints . . . better finish obtained.

FORGING — Replacing a lanolin-graphite mixture used on forging presses, Houghton's *Hot Forging Agent*, cut 50-50 with mineral oil, reduced cost of forging lubricant 67%. Die life was improved and forgings came through with better finish.

MARTEMPERING—Abundant proof of freedom from distortion due to interrupted quench is available. We cite just one instance: Ball-bearing races formerly were pre-heated, hardened, quenched (cold) air-cooled and drawn. Rejections were up to 10%. Process was changed to heating and martempering in salt. Result: no rejects; cost of heat treatment reduced from $.0417 to .0059 per race.

SALT BATH CARBURIZING—Houghton's *Perliton "W"* (water-soluble carburizer) replaced former cyanide bath used to case-harden roller bearing end plates. Time reduced from 10 to 5 minutes, with greater hardness and elasticity without fracture. Furnace produced 30% more work per day with Perliton "W." That's economy!

GRINDING—An aircraft plant changed to *Antisep Soluble Oil* as a grinding coolant, after complaints on finish. Antisep cost was $.0097 per gallon, diluted, as against .0203 per gallon for former coolant. Finish was improved. That's saving!

RUST REMOVAL AND PREVENTION—A spring manufacturer had stored steel wire which was later found to have rusted. To remove rust and protect the wire during subsequent forming operations, *Houghto-Clean Rust Remover* was used, diluted 1 to 3 with water. After water rinse, the wire was dipped in Houghton's Rust Veto 266, a fingerprint neutralizer and preservative. Pickling not necessary. Here was a saving in both material and in processing.

●

Those are but quick sketches of cas studies reported by users. Want more? Or, want to know how these products and the "Know-How" behind them can be applied to your operations to cut costs? Then ask the Houghton Man when he calls, or write to the address below. It's headquarters for metal-working ideas and materials.

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Where a continuous record of atmosphere readings is required, the indicator can be co-ordinated with a recorder.

You can't afford to be without this instrument any longer.

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Transition Temperatures

(Starts on page 558)

ing Research Supplement, February 1948, p. 50-s to 68-s.

The flat plate tension specimens were 12 in. wide, internally notched, and 3 in. wide, externally notched. The internal notch consisted of a hole ¾ in. in diameter drilled in the center of the 12-in. width, with sawcuts on each side of the hole extending normal to the long axis of the specimen for a total span of 3 in. The external notch consisted of a sawcut on each edge of the 3-in. wide specimen extending in for about ½ in.

The authors define transition temperature as "a temperature at which the mode of fracture changes from the ductile shear type to the brittle cleavage type". Since, in this program of tests, the cost of testing a large number of the "restrained welded" type of tension specimen would have been prohibitive, it was necessary to approximate the transition temperature of each steel by arbitrarily choosing a point halfway between two adjacent test temperatures, one of which gave a predominantly shear fracture and the other a predominantly cleavage fracture. Thus it is indicated that the transition temperature selected for any of the steels tested with this type of specimen may be in error by as much as 20° F., because temperature differentials between test specimens were sometimes quite large. However, transition temperatures established by tests of the 3 in. wide edge-notched tension specimens, as determined by type of fracture, are believed to be correct to within 5° F., since a large number of these specimens could be tested rapidly and inexpensively.

The four low-alloy steels tested in the quenched and tempered condition were as follows: Steel 1—yield 66,000 psi., tensile 89,000 psi., 0.19% C, Mn-Mo; Steel 2—yield 80,000 psi., tensile 97,000 psi., 0.14% C, Si-Cr-Mo; Steel 3—yield 80,000 psi., tensile 100,000 psi., 0.16% C, Mn-Ni-Mo-V; Steel 4—yield 84,000 psi., tensile 100,000 psi., 0.16% C, Cr-Ni-Mo.

As a basis for comparison, similar tests were also made using a mild steel (Br of a previous investigation) of 36,000 psi. yield strength and 0.15% C, in the as-rolled condition.

(Continued on page 566)

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IS ONLY AS GOOD AS THE DIAMOND IT USES

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Dependably accurate "Rockwell" testing results are obtained only when every part of your hardness testing equipment is made to precision limits. That is why a correctly designed diamond penetrator is of such great importance. Always specify CLARK Diamond Cone Penetrators, both for Standard and for Superficial "Rockwell" testing. They are accurately made to the proper size and shape; exactly formed by expert lappers. CLARK Penetrators are designed for use on all "Rockwell" type testing machines.

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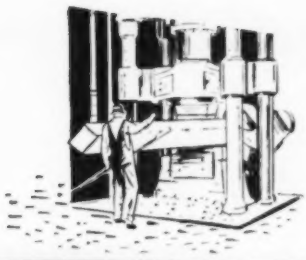
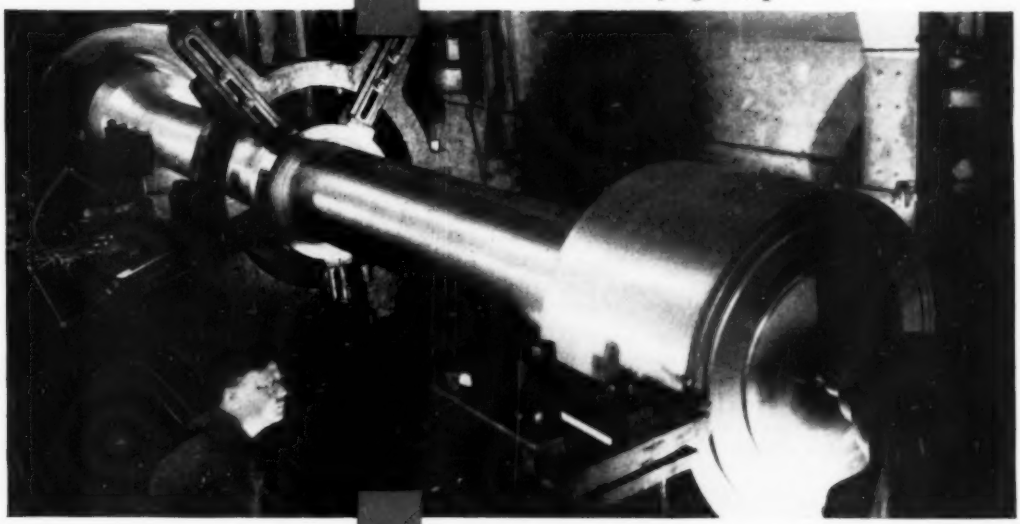
FORGINGS BY FINKL





THIS IS A 46" blooming mill spindle weighing almost 22 tons in the "as forged" condition. It is 24'-10" long and will weigh 18 tons when finished. It was press forged from a 54" ingot weighing 55 tons.

Its highly stressed application in a blooming mill demands strength, stamina, and high fatigue resistance for long life and the utmost in service. Finkl craftsmen build every specification into the job in each stage of its development . . . from research laboratory to finished product.

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Outstanding DYNALOG* Electronic Recorders and Controllers

The extreme simplicity of Dynalog Electronic Instruments results in unmatched accuracy, sensitivity, and speed... unequalled freedom from maintenance. Designed to take full advantage of electronic circuits, these instruments provide completely *stepless* continuous balancing. Full scale to complete balance in as little as 1 second (5 seconds, standard). Dynalog is the only potentiometer that has

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Indicators, recorders and controllers available for measurement and control of high temperatures (up to 2800°F.) with thermocouples, low temperatures (up to 600°F.) with electric resistance bulbs, pH with Beckman electrodes, force with electronic force cells, weight with electronic weight cells. Controllers also available with pneumatic or electrical control systems, for on-off, proportioning, or automatic reset control.

Multi-Record DYNALOG* A 6-in-1 Instrument

The *Multi-Record* Dynalog actually takes the place of as many as 6 recording instruments. Every 6 seconds a point is measured and recorded... up to 6 points in 6 different colors on 1 round chart, with only 1 measuring system. Records are practically continuous lines. Chart costs are cut to minimum.

Reg. U. S. Pat. Off.

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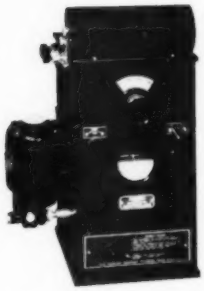
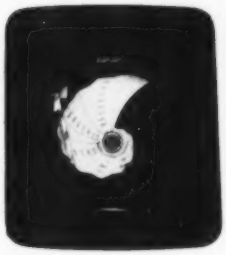


NON-RECORDING CONTROLLERS

Top performance of the Type 4000 controllers has been proven over many years of service. A single motor can operate up to 5 instruments . . . affords large saving in both initial and operating costs. Control is electric . . . action, on-off, or proportioning.

PROGRAM CONTROLLER

When used with Type 4000 controller, this time-temperature cam setting unit varies control point to carry out any program. Different rates of rise, holding periods and other variations can be combined on the same cam. Mechanism is extremely simple and trouble-free. Aluminum cams, printed with time and temperature scales . . . can be laid out and cut by operator.



STRONG ACID PICKLING

Type 4000 Non-Recording Temperature Controller

Simpler, fewer, larger, and more rugged parts make the Type 4000 particularly free from maintenance problems and expense. The electrical measuring system permits controller to be located any distance from bath, away from corrosive atmosphere. Thermal elements easily replaced on the job at small cost if damaged by acids or accident. Equipment can be supplied with simple, dependable, pneumatic or electrically-operated control valves.

Foxboro strong acid thermocouples stand up in severe solutions required for pickling stainless steel. Reduce maintenance costs.

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With Foxboro pressure indicators, recorders or automatic controllers, gas or oil pressures for furnace burners can be maintained efficiently . . . compressors controlled effectively . . . hydraulic systems controlled accurately . . . steam pressures properly indicated or recorded . . . and many similar functions performed to streamline costs. Instrument ranges; from 1" of water to 12,000 pounds.

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Accurate, automatic control of heating, or heating and cooling, in plating tanks, cleaning baths, degreasers, and wash tanks by these instruments assures top quality at low cost.

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Pangborn
BLAST CLEANS CHEAPER
with the right equipment for every job

Transition Temperatures

(Starts on page 558)

The transition temperatures determined by type of fracture of the three forms of test specimen used in this study are as follows:

Steel	Restrained Welded	3-in. Wide Edge-Notched	12-in. Wide Internally-Notched
1	40° F.	−10° F.	5° F.
2	75	18	20
3	−50	−102	−95
4	−65	−108	−102
Br	58	20	18

It is indicated that the transition temperatures determined by the large restrained specimens are approximately 40 to 50° F. higher than the temperatures determined by the small notched specimens. Thus it seems that the geometry of the specimen may be responsible for a shift of the transition temperature to a higher value as the size and degree of restraint afforded by the shape of the specimen are increased.

It is also interesting to note that the fracture of the large "restrained welded" specimen invariably occurred at stress values in the main strength member below the yield strength of the steel as determined by standard tensile tests.

The authors point out that transition temperature is in itself not the only criterion in evaluating the performance of steel for low-temperature service. The transition temperatures of Steels 3 and 4 were almost the same, but the energy absorbed by Steel 4 was much greater at any testing temperature than the energy absorbed by Steel 3.

Two types of electrodes were used in the fabrication of the large "restrained welded" tension specimens, one a Type 310 stainless of 25-20 Cr-Ni composition and the other a manganese-molybdenum ferritic type with a low-hydrogen mineral coating. A preheat of 300° F. was used with the 25-20 electrode and a preheat of 175 to 200° F. with the ferritic electrode. Prior to welding any of the specimens, each batch of electrodes was heated at 600° F. for at least 1 hr. A period of from 24 to 48 hr. was allowed between the completion of the welding and the start of testing, except for one or two samples.

The authors point out that these two electrodes were found to give satisfactory performances in large welded structures subjected to plastic strain at low temperatures.

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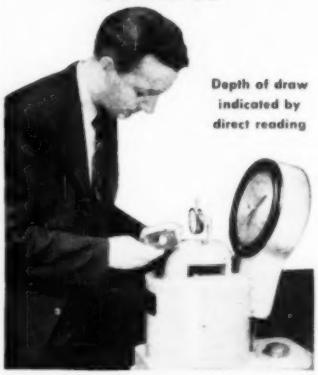

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THOUSANDS of dollars of scrap material can often be saved by making this simple cup test. A flick of a switch operates machine. Speed of piston travel is adjustable within a wide range by simple dial setting. Load is applied automatically and uniformly to grip the specimen, followed immediately by penetrator to form cup. Pressure is accurately shown on large gauge with maximum indicating hand; depth of draw shown on depth indicator. Hydraulically operated. Model PA-2 has 15,000 lb. capacity for stock up to $\frac{1}{16}$" thick; Model PA-3 has 30,000 lb. capacity for stock up to $\frac{1}{4}$" thick. Write for literature.

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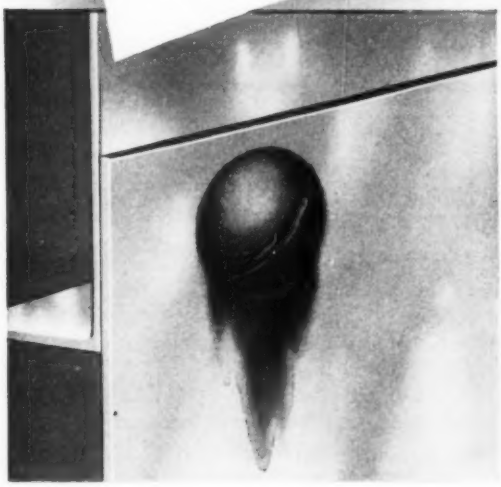
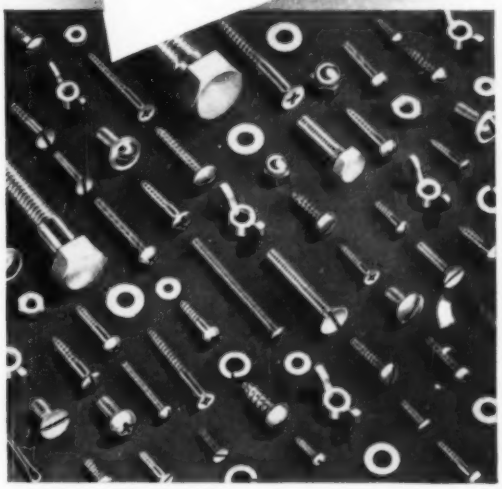


WITH FASTENERS LIKE THESE



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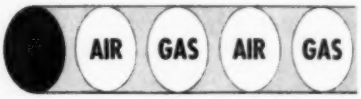
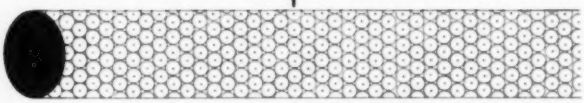
SOME HAVE IT THIS WAY....

SOME HAVE IT THAT WAY....



MANY HAVE IT KEMP-WAY!



View of gas pressure governor, part of air inlet and air check valve, mixing chamber and turbo-compressor.

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IMP-10

WHAT'S NEW
IN MANUFACTURERS' LITERATURE

787. Abrasives

Attractive 32-page two-color book presents the outstanding features of new, modern factory for production of quality abrasives. *Carborundum Co.*

788. Acid Diluting Equipment

"Karbate" brand sulphuric acid diluting equipment is described in new catalog M-6843. *National Carbon Co.*

789. Alloy Steels

Critical points of 85 standard carbon and alloy steels, legibly printed on a lasting celluloid pocket card 2¾ x 4¾. Includes Ac1, Ac3, Ar1, Ar3, and Ms temperatures for A.I.S.I. and S.A.E. types in current use. *Republic Steel Corp.*

790. Alloys

New booklet contains interesting "picture story" of the development of "Q-Alloys" down through the years, highlighting the most unusual castings produced for specialized problems in a list of more than 30,000 patterns. *General Alloys Co.*

791. Alloys, Fabricated

New catalog is available showing cost-cutting fabricated heat treating equipment for higher pay loads and better quality. *Rolock, Inc.*

792. Bars, Forging

There is a stainless steel "tailored" to fit your specifications for chemical and physical properties. Write for 112-page booklet of forging data, "Evaluating the Forgeability of Steels". *Timken Roller Bearing Co.*

793. Blast Cleaning

New bulletin 211-A describes floor-blast equipment for faster, more economical cleaning of metal parts. *Pangborn Corp.*

794. Brazing

Easy-Flo simple, versatile method of fabricating ferrous, nonferrous and dissimilar metals is described in bulletins 12-A and 15. *Handy & Harman.*

795. Brazing Alloy

Extruded Flow-Copper, the uniform brazing alloy for copper, brass and bronze, is discussed in new 15-page booklet along with recommended fluxes and "know how" of the process. *Westinghouse Electric Corp.*

796. Camera, High Speed

"Magnifying Time", a new folder describing high speed camera capable of 1000 to 3000 pictures per second. Particularly adaptable for close inspection in machine tool operations and also for measuring flow of liquids as in chemical mixers, coolant flow, etc. *Eastman Kodak Co.*

797. Cast Irons

Fully descriptive booklet is available on the many advantages of Molybdenum Cast Irons. *Molybdenum Corp. of America.*

798. Castings

A complete tabular summary of engineering properties of various types of Mechanite castings is provided in new 4-page bulletin No. 32. *Mechanite Metal Corp.*

799. Castings

20-page booklet, "Micro Precision Castings", contains valuable technical information for manufacturers requiring small, accurate, alloy steel parts in quantity. *Michigan Steel Casting Co.*

800. Castings, Alloy

New bulletin, "Solving Corrosion Problems with Chem-Alloy High-Alloy Castings", features two important charts: a quick selector for corrosion resistance of most commonly used alloys, and a list of types and grades in standard alloys. *Electro Alloys Division.*

801. Castings, Alloy

Complete story of how to solve corrosion problems with nickel chrome alloy castings is given in new 24-page catalog. *Standard Alloy Co., Inc.*

802. Coatings, Protective

Latest 4-page bulletin on Ucflon protective coatings gives information on four groups especially developed for corrosion control, chemical resistance and heavy-duty industrial painting. *United Chromium, Inc.*

803. Combustion Control

"Combustion Control for Industry", a new fact-filled free booklet now available, shows how greater savings can be realized by proper combustion in heat treating units of any size. *Cities Service Oil Co.*

804. Combustion Safeguard

New bulletin W1816 describes application of Pyrotol in protecting gas-fired ovens, furnaces and other industrial heat treating equipment from danger of gas explosions during ignition operation and shut-off. *Bristol Co.*

805. Control Valves

Series 700 Diaphragm Control Valves is subject of new catalog giving mechanical and flow characteristics of this air-operated diaphragm motor-controlled valve. *Brown Instruments Co.*

806. Conveyor Belts

Illustrated booklets, sent on request, describe conveyor belts designed for use in transportable industrial applications. *Wickwire Spencer Steel Div.*

807. Copper

New 44-page booklet, in handy vest-pocket size, contains a number of interesting training lectures on Revere metals, their physical properties and countless uses. *Revere Copper & Brass, Inc.*

808. Corrosion

Complete line of quality rust preventives, both oil and petroleum-types for interior and exterior use, described in booklet "Gulf Rust Preventives". *Gulf Oil Corp.*

809. Cutting Oils

For the right combination to suit your specific requirements, write for the booklet "Cutting Fluids for Better Machining". *D. A. Stuart Oil Co.*

810. Die Casting

Revolutionary injection pressure multiplier assures solid, dense castings. Built into the hydraulic injection cylinder — requires no additional space. This and other machines to meet every die-casting requirement are described in catalog. *Kux Machine Co.*

811. Die Castings

Revealing book "How Magnesium Pays" gives case studies of the economical use of magnesium in a wide range of products. *Dow Chemical Co.*

812. Drawing Compounds

New leaflet available on several recently developed compounds made especially for use on different types of metals in stamping or drawing operations. *E. F. Houghton & Co.*

813. Electrodes

Write for new pocket-size electrode catalog, GEC-452 with index and description of an electrode to suit every application. *General Electric Co.*

814. Electroplating

Metal Fluoborate Solutions are described in technical bulletin XP-1, which outlines new approach to zinc plating. Bulletin LTP-1 describes lead-tin alloy plating from Fluoborate Bath and Manual CP-1, copper fluoborate. *General Chemical Div.*

815. Forging

Bulletin 01-A describes new wide adjustment forging rolls available in six sizes for pre-rolling ingots from ensuing to largest in fast, accurate, automatic operation. *Ajax Mfg. Co.*

816. Furnace

Bulletin 120 describes L-type furnace designed for complete atmosphere protection from start to finish, with pre-heat, high heat and quench combined in one unit. *Lindberg Engineering Co.*

817. Furnaces

New catalog on Heroult pantry-type electric melting furnace with patented roofing to assure speedy and simple bricking and elimination of steel shapes. *American Bridge Co.*

818. Furnaces

Catalog 110 features new heat treating furnaces and atmosphere charts. *C. I. Hayes, Inc.*

819. Furnaces

Bulletin HD-641 gives construction details and complete specifications on 20 sizes and types of furnaces for laboratory use. *Heat Duty Electric Co.*

820. Furnaces

New 32-page fully illustrated catalog on Vapocarb-Pump furnaces. Describes the triple-control method of regulating atmosphere and features improved control by use of fluid pump assembly. *Leeds & Northrup Co.*

821. Furnaces

New 72-page bulletin No. 110 describes electric salt bath furnaces and tools many uses in hardening, annealing, brazing, tempering, quenching, etc. *Ajax Electrothermic Corp.*

822. Furnaces

Attractive new bulletin "Cyaniding in Continuous and Batch-Type Furnaces" describes new applications in dry cyaniding. Ask for bulletin EC-145. *Surface Combustion Corp.*

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823. Furnaces

For full information on clean hardening, annealing, normalizing, carburizing, etc., write for Bulletin 801-A. *American Gas Furnace Co.*

824. Furnaces

For full information on uniform, low-cost operation, write for bulletin 461. It illustrates 17 sizes and types with brief descriptions of each. *Electric Furnace Co.*

825. Gas Burners

Latest methods of obtaining highest heating efficiency per unit of fuel are illustrated in bulletin K-21 on Kemp Series "S" industrial carburetors. *C. M. Kemp Mfg. Co.*

826. Gray Iron

Mechanical and engineering characteristics of gray iron, with details for designing cast components, all combined in new booklet furnished on request. *Gray Iron Founders' Society.*

827. Hardness Testers

Bulletin DH-114 contains full information on Tukon Hardness testers for use in research and industrial testing of metallic and nonmetallic materials. Also included is bulletin DH-7, giving experiences in various fields. *Wilson Mechanical Instrument Co.*

828. Heat Treating

New bulletin now available on Series T Ipsen automatic heat treating unit for lower costs and efficient operation. *Ipsen Industries, Inc.*

829. Heat Treating

Pressed steel lightweight sheet alloy heat treating units furnished in any size, design or specifications. Write for full information on this. *The Pressed Steel Co.*

830. Heat Treating

Form 7340 C, an 8-page illustrated article, contains interesting story of the conveyorized harden, quench and draw installation at American Fort Pitt Spring Division. *Sonneborn Stewart Industrial Furnace Div.*

831. Induction Heating

Learn the many advantages of applying Tocco induction heating for hardening, brazing, soldering, annealing or forging operations. Send for free booklet now available. *Ohio Crankshaft Co.*

832. Microscopes

New catalog D-104 contains a full description of the phase contrast principle, with an article on proven uses, plus actual photographs taken with these accessories. *Bausch & Lomb Optical Co.*

833. Nickel Alloys

Improve structure and machinability of your gray iron castings and reduce machining time, tool wear, rejections, by using small indie additions of Nidicy, described in new booklet. *International Nickel Co.*

834. Phosphor Bronze

New technical data book available with information on all the latest developments in efficient equipment. *The Phosphor Bronze Corp.*

835. Polishing

New booklet "Polishing Cloth and Abrasives" furnishes first-hand description and classification of some of the most used but least described accessories in modern sample preparation. *Buehler, Ltd.*

836. Potentiometers

Dynalog instruments for control of temperature, humidity, pressure, flow, etc. Details in bulletin 427. *Foxboro Co.*

837. Powershears

New 40-page catalog gives latest information concerning Di-Acro powershears among other new items for die-less duplicating process. *O'Neil-Irwin Mfg. Co.*

838. "Precisionomics"

A new house organ issued every-other-month will feature articles directed to the scientist and laboratory worker engaged in the petroleum and metallurgical fields. *Precision Scientific Co.*

839. Pyrolance

New bulletin 1734-D includes photos, complete description and prices of the Pyrolance for temperature readings of molten metal in nonferrous foundries. *Illinois Testing Laboratories, Inc.*

840. Recorders

Condensed catalog Z4500 gives full description of Capacitog Recorder and other instruments for application in all types of laboratory classifications. *Wheelco Instrument Co.*

841. Refractories

New 4-page leaflet No. 312 discusses properties and applications of Taylor Sillimanite (TASIL) special refractories. *Chas. Taylor Sons Co.*

842. Refractory Concrete

Detailed information furnished on methods of using refractory concrete in annealing furnaces. *Lumnite Div., Universal Atlas Cement Co.*

843. Salts

New manual contains more than 70 pages of material on heat treatment with molten salt baths. Fully illustrated. *E. I. duPont de Nemours & Co., Inc.*

844. Spectrographic Source Units

Precision control in spectrographic analysis to fit your specific requirements. Bulletin 300 describes flexible, new spec-power units. *National Spectrographic Laboratories, Inc.*

845. Steel Sheets

Characteristic properties of US electrical steel sheets are shown in curves and tabular form in new 180-page illustrated engineering manual No. 3. *Carnegie-Illinois Steel Corp.*

846. Steel, Zinc-Coated

Fully illustrated booklet "Armco-Zincgrip-Paintgrip" tells how this special-purpose steel sheet furnishes high corrosion resistance as well as stretch quality for sharp bends or flat parts of fabricated products. *Armco Steel Corp.*

847. Steels, Alloy

New 24-page booklet "How to Specify and Buy Alloy Steel with Confidence" emphasizes the importance of careful selection, positive knowledge of properties and accurate heat treatment in purchasing alloy steels. *Jos. T. Ryerson & Son, Inc.*

848. Steels, Stainless

Consistently fine stainless steels selected to resist nitric acid on the inside surface, and atmospheric conditions on the outside. Write for more detailed information on Vancoram Perro Chromium steels. *Vanadium Corp. of America.*

849. Thermocouples

A new 34-page catalog, Reference H, will furnish complete data on thermocouples, quick-coupling connectors, thermocouple wire, lead wire, protection tubes, etc. *Thermo Electric Co.*

850. Thermocouples

Catalog 59-B tells complete story about use of Chromel-Alumel couples and extension leads. *Hoskins Mfg. Co.*

851. Thermometers

New 16-page catalog "T" C. Laboratory Thermometers and Hydrometers illustrates and describes complete line of these instruments for use in chemical and industrial laboratories. *C. J. Tagliabue Corp.*

852. Tool Steels

Write for new 176-page handbook, "The Tool Steels of Allegheny Ludlum", covering all the leading types and grades of tool steels. *Allegheny Ludlum Steel Corp.*

853. Tool Steels

New booklet "Bethlehem Hot-Work Tool Steels" describes versatility for such applications as crowners, dollies, hot punches, stamps, striking dies, trimmers, and gripper dies. *Bethlehem Steel Co.*

854. Tool Steels

Attractive new booklet gives details and uses, composition and heat treatment of carbon and carbon-vanadium tool steels. *Vanadium-Alloys Steel Co.*

855. Tubing

New 24-page manual contains useful data on stainless steel tubular products, including physical properties, fabricating data, corrosion resistance, etc. *Peter A. Frasse & Co., Inc.*

856. Turbines

Bulletins available as follows: Data book 107, Gas Scavengers 109, Power-Soaring 110, Steel Units 122, Foundry 112, Description bulletin 127 and Technical bulletin 136. Send for each by number for particular application. *Spencer Turbine Co.*

857. Welding

Two new pantograph-type gas cutting machines are described in a 12-page illustrated folder showing machines at work on typical jobs and including four tracing devices used in machine gas cutting, electronic, magnetic, manual and spindle operations. *Air Reduction Sales Co.*

858. Welding Bronze

How to save material by bronze welding, an ideal combination for repair welding, building up worn surfaces and production welding, described in new 17th edition of B-13. *American Brass Co.*

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METAL PROGRESS

7301 Euclid Avenue, Cleveland 3, Ohio

October, 1949

787	804	821	838	855
788	805	822	839	856
789	806	823	840	857
790	807	824	841	858
791	808	825	842	
792	809	826	843	
793	810	827	844	
794	811	828	845	
795	812	829	846	
796	813	830	847	
797	814	831	848	
798	815	832	849	
799	816	833	850	
800	817	834	851	
801	818	835	852	
802	819	836	853	
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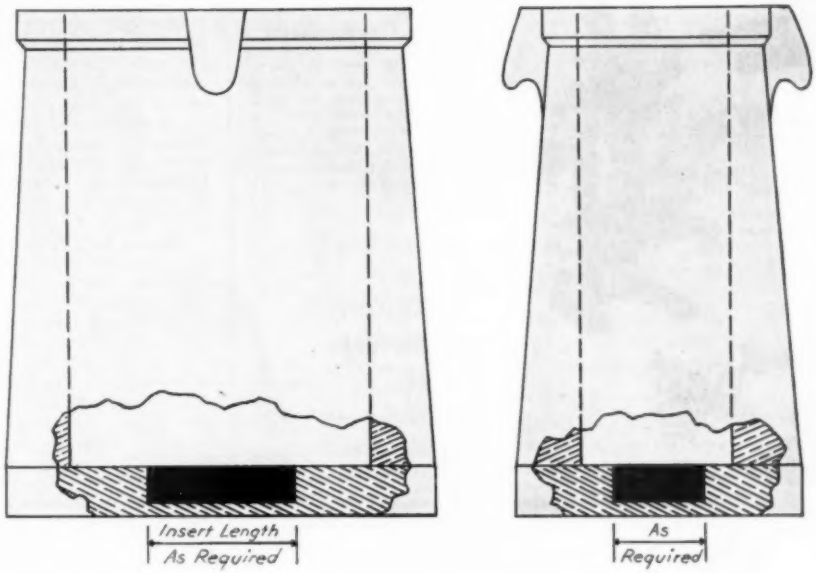

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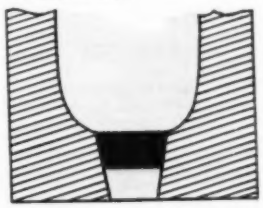

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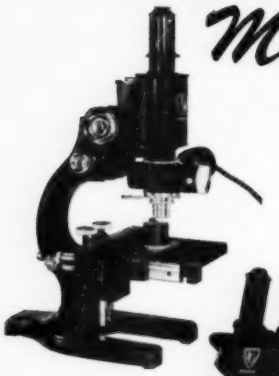

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Two distinct advantages are offered by these instruments:

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The Physics of Powder Metallurgy

(Starts on page 515)

of a gradient of vacancies. However, the rates which can be derived theoretically for these two mechanisms are different. According to the authors, the geometry existing under the conditions of the first test series (small radius of curvature) is responsible for the fact that the rates observed can best be explained by a diffusion, rather than a viscous flow, mechanism. Hausner and Dedrick presented a series of data on the resistivity and the temperature coefficient of resistivity of metal powder compacts as a function of powder particle size, compacting pressure, sintering temperature and sintering time. On the basis of these data the authors derived some general relationships on the influence of these variables on resistivity and temperature coefficient of resistivity. The authors expressed their belief that the relationships may help in developing a generally acceptable theory of sintering.

Papers by C. Herring on "Surface Tension as a Motivation for Sintering" and by J. K. MacKensie and R. Shuttleworth on "A Phenomenological Theory of Sintering" were entirely theoretical. The paper by MacKensie and Shuttleworth was read only in summary. Herring derived equations for the rate of material transport in metallic crystals due to surface tension as a motivating force. The equations were based on the concept of differences in chemical potential in a crystal due to differences in temperature, pressure, strain, and number of lattice vacancies. Herring outlined with great care the assumptions on which the derivations are based. However, since the validity of his assumptions is not yet generally established, Herring's theory will require experimental proof before it can be generally accepted.

A paper by P. Duwez and C. B. Jordan, "The Sintering of Copper-Gold Alloys", was the only one concerned with the sintering of a binary mixture of metal powders in the absence of a liquid phase. The paper is one of a series in which the authors investigate the metallographic and dilatometric changes during the sintering of such binary powder mixtures. Two superstructures of compositions AuCu and $AuCu_3$ are found in the

(Continued on page 572)

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Powder Metallurgy

(Starts on page 515)

copper-gold system. When compacts of a mixture of copper and gold powder corresponding to the formula $AuCu_3$ are sintered at temperatures below the maximum temperature at which AuCu is stable, the X-ray diffraction analysis of the sintered compacts will show largely lines corresponding to the compound AuCu and elemental copper. This indicates that AuCu is a particularly stable phase. At higher temperatures, lines corresponding to the disordered solid solution are found. The dilatometric curves show rapid expansion in the temperature range where the compound AuCu is formed.

Liquid Phase Sintering

Papers by F. V. Lenel on "Sintering With a Liquid Phase" and by R. Kieffer of Metallwerk Plansee, Reutte, Austria, on the "Sintering Mechanism of Carbide-Binder Compositions in the Presence of a Liquid Phase" were concerned with liquid phase sintering. Lenel presented some quantitative data on the rate of densification of 80% iron, 20% copper powder compacts made of different particle size fractions and different grades of iron powder. The rate of growth of the spherical iron particles in the microstructure during sintering was also measured. Kieffer's paper contained a detailed analysis of the sintering mechanism of cemented carbides, taking into account some of the recent investigations of the tungsten carbide – cobalt system. In his correlation of sintering mechanism and mechanical properties of the carbides, Kieffer emphasized the importance of the solution of cobalt in the tungsten carbide during sintering, which according to him results in a "healing" of the imperfections in this crystal and thereby contributes to the excellent strength and toughness of the cemented carbides.

Nucleation and Grain Growth

Five papers which treated various aspects of the nucleation, growth and structure of grains and subgrains were entitled: "Mechanism of Crystal Growth", by A. Smekal, Technische Hochschule, Darmstadt, Germany; "Nucleation", by J. H. Hollomon and D. Turnbull; "Recrystallization and Grain

(Continued on page 574)

NEWEST LAB FURNACE!

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Operating temperatures from 900°F. to 1850°F. are obtainable—precisely controlled by means of a manually operated 36-step, tap-changing transformer.

Outstanding characteristics of this new type furnace are rapid heating (about 85 minutes from cold to maximum temperature), and quick response to demand for temperature change.

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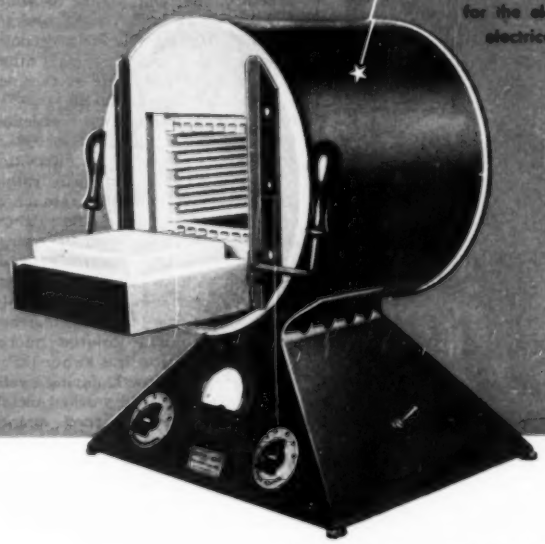
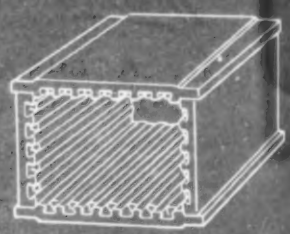
Whatever your electrical resistance problem, consult with us. In addition to world-famous Nichrome V and Nichrome, we make over 80 alloys for the electrical and electronic industries—the most complete line of electrical resistance alloys in the world.

New Model 851 Hevi Duty Muffle Furnace

Standard for use on 115 v. or 230 v., 50 or 60 cycles, A.C. Input: 1150 watts. Maximum operating temperature: 1850°F. 36-step control down to approximately 900°F. Heating elements: 22 gauge Nichrome V wire.



Heating units, top and bottom, are interchangeable; likewise, the two side units. All units are easily replaceable and reversible (permitting the coiled Nichrome V wire to be exposed or muffled).



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CUT-AWAY VIEW

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Powder Metallurgy

(Starts on page 515)

Growth", by P. A. Beck; "Recrystallization", by M. Balicki; and "Examination of Subgrain Structure With the Electron Microscope", by L. Delisle and G. A. Davis.

Smekal presented a summary of some of his investigations on nucleation, crystal growth and diffusion in rock salt crystals. He pointed out that the observation of these phenomena in ionic crystals is greatly simplified as compared with their observations in metals, for a number of reasons. Optical methods such as birefringence and infrared absorption can be used; structural defects in crystals colored through the presence of metal atoms can be directly observed; single crystals can be uniformly and evenly deformed and the rate of recrystallization into a new single crystal can be measured quantitatively. The author emphasized that the observations on ionic crystals should contribute greatly to a better understanding of similar phenomena in metallic crystals.

Hollomon and Turnbull developed equations for the rate of homogeneous nucleation on the basis of absolute rate theory. When these equations are applied to such phenomena as the fracture strength of liquids under negative hydrostatic pressure, the temperature to which metals can be undercooled, and the fracture strength of undercooled liquids (thin glass fibers), values can be derived for the surface energy of the liquids on the basis of the theory. The authors presented some experimental data in which great care was taken that nucleation should occur homogeneously rather than as a result of the presence of impurities. They were able to show that the values for surface energy derived from the experiments corresponded satisfactorily with those measured by conventional methods.

Beck's paper was distinguished by some exquisite colored micrographs illustrating the successive steps in grain growth during cyclical annealing of cold worked metal. His work was concerned mainly with the reasons for the preferred orientation that is so often observed after recrystallization, grain growth, coarsening, and secondary recrystallization have taken place. On the basis of numerous observations of these phenomena, Beck was able to show that the preferred orientation is generally due to the fact that

(Continued on page 576)

SEE IT on display at Hayes Booth No. 1842 at the Metals Show—

The FIRST controlled-atmosphere electric furnace ever sold!

Sold in 1927, and retired as a museum piece after 20 years, "Old Number One" is still a competent high speed steel hardening furnace. The features which C. I. Hayes Inc pioneered, later called "Certain Curtain," are still the basic essentials of THE MOST ECONOMICAL HEAT-TREATING, wherein the natural advantages of electric heat are combined with precision control of furnace atmosphere.

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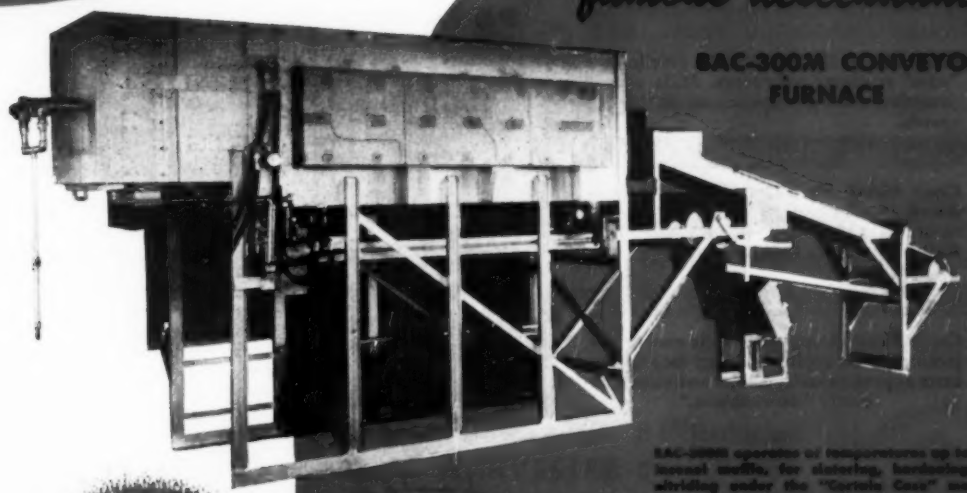

BAC-300M operates at temperatures up to 2300°F, with inert gas atmosphere, for sintering, hardening, and carbon-nitriding under the "Certain Case" method. Atmosphere may be hydrogen, dissociated ammonia, or combusted gas. Oil or water quench. Completely automatic, outstanding for economy of operation and low cost of product treated.

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Coast Metals Hard Cast Rolls hold down-time and idle labor to a minimum. They give more uninterrupted production and tonnage.

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Coast Metals Hard Cast Rolls give longer "runs" at closer tolerances. Mills report extended tonnage operations at higher speeds.

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Coast Metals Hard Cast Rolls have produced 2319 tons as compared to 150 tons in actual tests with tool steel rolls. Performance 15 : 1. Cost reduction per ton 79 per cent.

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Coast Metals Hard Cast Rolls enable adjacent "parts" (rolls, bearings etc.) to operate at peak capacity longer and eliminate costly "slow-downs."

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The Physics of Powder Metallurgy

(Starts on page 515)

grains which have certain preferred orientations have a much faster rate of growth than grains of other orientations.

Balicki's theory of recrystallization considers it as a rate process in which the conversion from the work hardened state to the annealed state takes place by way of an activated complex. The author showed that such a theory can explain the experimentally observed changes in properties during recrystallization. His theory would, however, predict random distribution of annealed domains in a partly recrystallized metal which is generally not observed. This difficulty is removed by postulating certain factors which bias an activated complex either favorably or unfavorably.

Delisle and Davis presented a series of excellent electron micrographs of the subgrain structure of metallic tungsten. Particular care was taken to show that the differences observed were not caused by differences in technique, but by actual differences in the structure, as affected by mechanical and heat treatment of the material. The sizes of the blocks which constitute the subgrain structure and their degree of disorientation within individual grains are within the same range as those derived from X-ray data and other techniques.

Diffusion

Diffusion was the principal subject of papers by M. Cohen, D. Bakalar, and F. S. Buffington on "Self-Diffusion of Iron", by R. Smoluchowski and M. R. Achter on "Grain Boundary Movements—Grain Growth" and by K. H. Butler on "The Role of Diffusion in Fluorescent Materials". Cohen and his co-workers determined the self-diffusion constants of alpha and gamma iron by the radioactive tracer method of Steigman, Shockley, and Nix, taking particular precautions to avoid preferential evaporation of the radioactive iron. Their results, which differ considerably from those previously reported by Mehl and Birchenall, can be represented by the following two equations:

Alpha iron between 814 and 906° C.:

$$D = 14e^{\frac{-62{,}000}{RT}}$$

(Continued on page 578)

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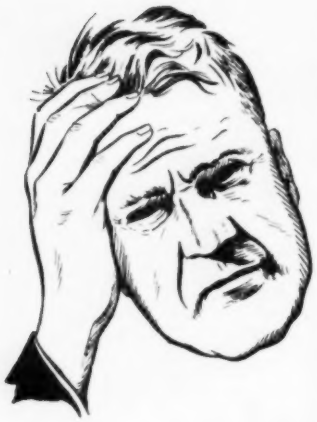

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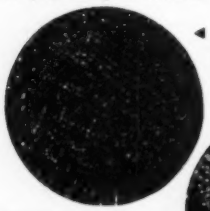

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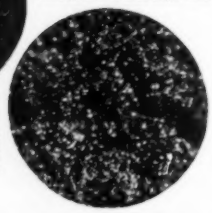

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Here the granular structure consists of little spheres of metal that cannot be held in place. Under frictional pull these gradually loosen and grind out. Wear and costly failure result.

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Yield Point	22,000 psi
Proportional Limit	11,500 psi
Elongation in 2 in.	15%
Reduction of area	11%
Modulus of Elasticity	13,000,000
Ultimate Compression	50,000 psi
Ultimate Shear	45,000 psi
Linear coefficient of thermal expansion	.000011
Brinell Hardness	80

(10 mm ball, 500 KG load, thirty seconds)

American NON-GRAN Bronze Company

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Powder Metallurgy

(Starts on page 515)

Gamma iron between 1062 and 1393° C.:

$$D = 0.52e^{\frac{-67,500}{RT}}$$

By extrapolation the authors find that the diffusion constant of alpha iron is 280 times that of gamma iron at the transformation temperature. Smoluchowski and Achter observed the diffusion of silver in copper. At low temperatures this diffusion takes place preferentially along grain boundaries. The aim of the investigation was to show that this grain boundary diffusion is influenced by the orientations of the boundaries. The experimental results show that diffusion seems to have proceeded along certain grain boundaries, though not along others, but the discussion to the paper brought out other possible interpretations of the results than that of preferential diffusion along grain boundaries having certain orientations. Butler's paper was of minor interest to metallurgists.

Preparation and Properties of Powders

The remaining six papers were concerned with the preparation and properties of metal powders and the pressing operation. A paper by V. Fattinger of the Technische Hochschule, Graz, Austria, was entitled "Experiments With a View to Producing Pure Titanium Carbide Powder by Means of Carbonizing Gases Favorable to the Reaction". The author showed that the reaction between titanium dioxide and carbon can be catalyzed very effectively by letting it proceed in an atmosphere of carbon tetrachloride or chloroform, rather than in hydrogen or a vacuum. A. D. Power and I. Kakascik presented a paper entitled "Use of the Electron Microscope in Evaluation of Particle Size and Distribution", which illustrated the application of this new method of particle size determination to tungsten powder. B. Kopelman, in his paper "Nature of Metal Powders Prepared by Reduction of Oxides", discussed the structure of tungsten powders. He showed how the pycnometrically-determined density of the powder varies with the time and temperature of reduction because of the effects of pore shrinkage due to sintering and pore expansion due to entrapped water

(Continued on page 580)

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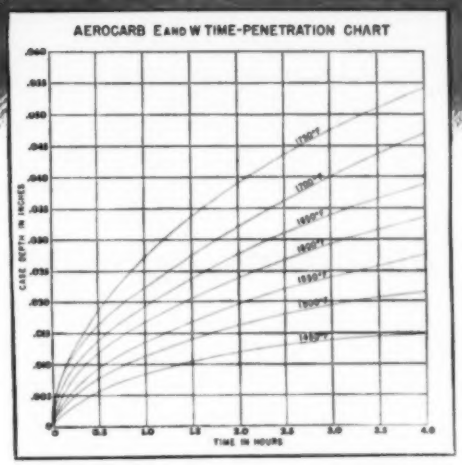

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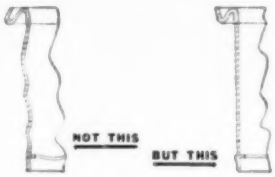

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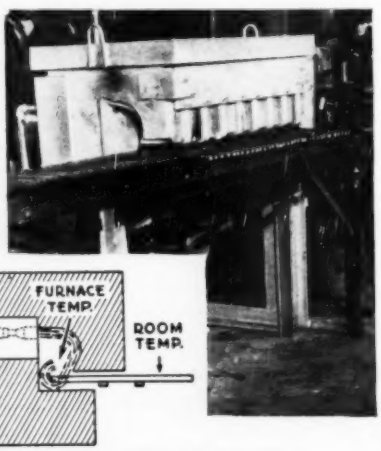

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Powder Metallurgy

(Starts on page 515)

vapor. G. C. Comstock's paper "The Preparation of Alloy Powder Products From Fully Alloyed Powders" presented a discussion of the methods for producing alloy powders and gave a few selected data on the properties of compacts made from such powders. R. P. Seelig's paper, "Fundamentals of Pressing of Metal Powders", contained a series of experimental data on the density, strength and electrical resistivity of green copper powder compacts as a function of particle size, lubricant addition, rate of load application, temperature of pressing, number of pressure applications, and holding time under pressure. The author also reviewed the various theories on the strength of pressed metal powder compacts. C. G. Goetzel, in his paper "The Principles and Present Status of Hot Pressing", gave a review of his subject, in which he emphasized the limitations of hot pressing. At the present time, its commercial applications are restricted to the cemented carbide field.

Mg-Hg-Mn Alloys*

A MASTER ALLOY containing 11% Hg was obtained by adding liquid mercury to molten magnesium. The master alloy was added to a melt containing 1.87% Mn and the cast billets and plates reduced to rods and sheet. Up to 2% Hg could be incorporated that way in the wrought metal and, with up to 1% Hg, the mechanical characteristics did not differ much from the regular alloy's, except that the elongation was somewhat better. It is stated, however, that *one* alloy containing 0.38% Hg had a 40-50% higher yield point (35,000 against 25,000 psi.) and a higher tensile strength (42,000 against 35,000 psi.) when treated for fairly short periods between 200 and 305° C.

Corrosion tests in solutions of sea salt or nitre showed that mercury-containing alloy was more corrosion resistant than the regular alloy. This sounds somewhat strange if compared to the author's statement that the microsamples did not have to be etched, for the water used in polishing etched their grain boundaries.

*Abstracted from "The Influence of Mercury on Wrought Mg-Mn Alloys", by W. Bulian, *Metallforschung*, Vol. 2, 1947, p. 158-160.

A simple way to DO something about ECONOMY-IN-PRODUCTION

EASY-FLO brazing this motorcycle handlebar instead of welding it saved 8c per assembly—a saving that grows big when you multiply it by thousands of assemblies.

Everybody is talking about economy-in-production. It's the keynote of the Metal Show to be held in Cleveland, October 17 to 21. But what counts most is *doing* something about it. In some cases, of course, that's not always so easy. There are, however, hundreds of fabricating operations where economy could be quickly effected by using methods which can be readily adopted.

One such method that offers quick results is *EASY-FLO* and *SIL-FOS low-temperature silver alloy brazing*. It has boosted production and cut costs on thousands of products. Illustrated are a few typical tried and proved ways to

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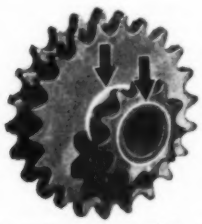
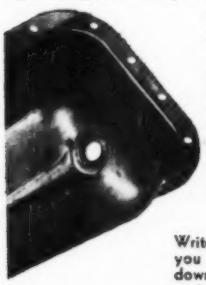


Big savings are possible on many parts now machined from the solid by changing to a built-up assembly brazed with EASY-FLO. The triple-sprocket above and hose nozzle adjusting part at right are good examples.

Plenty can be saved on many parts now cast, by changing to EASY-FLO or SIL-FOS brazed construction. The gas burner (above), once an iron casting, is now made of tubular steel members EASY-FLO brazed at about 50% lower cost.

Finishing is another operation on which EASY-FLO and SIL-FOS brazing can save plenty. The maker of the EASY-FLO brazed bike frame (above) says—"This method produces joints of great strength which are absolutely clean—free from excess brazing metal—making possible a better looking enamel finish".



Attaching spuds to many types of equipment can be done faster and cheaper with EASY-FLO and SIL-FOS brazing. Using EASY-FLO and induction heating, instead of soft soldering by hand, reduced cost on the automobile oil pan spud (left) from $11.00 to $4.50 per hundred.

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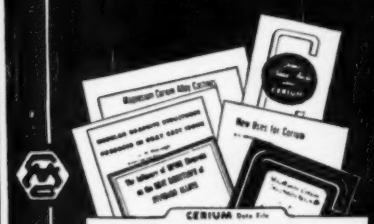

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Internal Stresses in Spot Welds*

THE STRESSES resulting from spot welding and their distribution in several welding configurations were determined experimentally, using the X-ray method of analysis. The spot welds were made in thin steel sheets (2.6 mm.) of the following composition: 0.2% C, 0.49% Si, 2.14% Mn, 0.025% P and 0.024% S. The sheets were pre-stress relieved for 3 hr. at 600° C. and furnace cooled. The specimens were 140 mm. in diameter and the welding time was 0.8 sec. Each spot weld had a 10-mm. penetration zone and a 12-mm. heat-affected zone.

Measurements were made on the following test pieces: *(a)* a single "heat spot" in the center of the specimen, using the same welding conditions as for making a spot weld; *(b)* a single spot weld joining two specimens in the center; *(c)* two specimens joined by a double row of three spot welds each. In the latter test the centers of the spot welds were 30 mm. apart. X-ray diffraction measurements were made at 10-mm. intervals, the first being made at a location 10 mm. from the center of the spot weld.

Around the single "heat spot", the radial and tangential stresses were equal but opposite in sign, the former being tension and the latter compression. The stresses varied inversely with r^2 (r = distance from the center of the spot weld) approaching zero at about 30 mm. from the center. The maximum stress was 30 kg. per sq. mm. (43,000 psi.). At locations less than 10 mm. from the center of the spot, plastic deformation had taken place. The same relationships were found for the single spot weld and the double-row welded specimens, except that at the intermediate heat-affected zone the tangential compressive stresses changed to small tensile stresses. On the single spot weld specimen, measurements on both the top and bottom sides yielded equivalent values. The results are in good agreement with theoretical relationships for magnitude and distribution of internal stresses in spot welds as they have been reported in the literature.

*Abstracted from "Internal Stresses in Spot Welds", by Viktor Hauk, *Zeitschrift für Metallkunde*, Vol. 39, 1948, p. 276-279.

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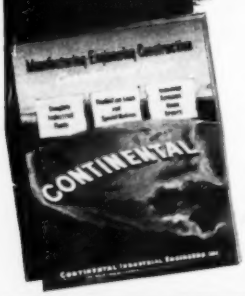

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Creep Strength of Cr-Ni Austenite*

THE INFLUENCE of the chromium and nickel contents and of small additions of titanium on the creep strength at 600 and 700° C. (1110 and 1290° F.) of austenitic iron-chromium-nickel alloys was determined. The austenitic alloys contained from 10 to 28% Cr and 8 to 60% Ni, remainder iron. The creep strength was reported as the stress necessary to cause a strain rate of 10^{-6} per hr.

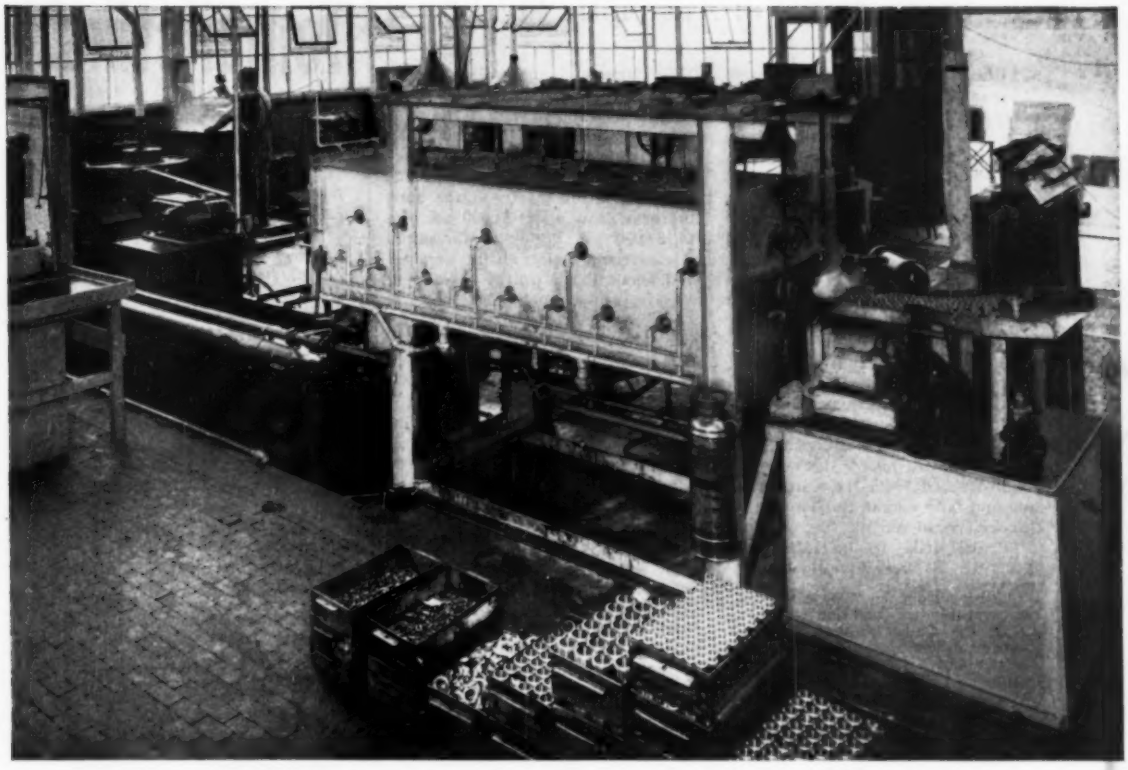
In alloys containing 20% Cr, the creep strength at 1110° F. increased from less than 5700 psi. at 1% Ni to a constant value of 11,400 psi. at nickel contents of 10 to 60%. That is, additions of nickel had no influence on creep strength in the range of nickel contents corresponding to the existence of austenite. At 1290° F. the constant stress value was about 4270 psi.

In 15% Ni alloys, when the chromium content was increased through the austenite range (from 10 to 25% Cr) the creep strength changed only from about 9960 to 12,000 psi. at 1110° F. At 1290° F. the increase was from 2840 to 4270 psi. Thus, changing the chromium or nickel content of these alloys in the austenite range has little effect on the creep strength. This is to be expected because the atom diameters of these alloying elements differ by only 1 or 2% from iron.

On the basis that they have crystal structures and atom diameters different from austenite, the following four elements would appear to be effective in increasing the creep strength of iron-chromium-nickel alloys: molybdenum, tungsten, columbium and titanium. The influence of adding up to 1.2% Ti to 18-8 and 14-14 Cr-Ni commercial steels is shown. The creep strength of 18-8 at 1110° F. increases from 11,400 to 15,600 psi., while that of 14-14 increases from 11,400 to a maximum of 12,800 and then drops off to 8500 psi. The difference may be associated with the fact that 14-14 becomes magnetic in the high-titanium range.

The results of this investigation indicate that the strengthening effects of the four alloying elements may be caused by lattice stresses rather than dispersion hardening.

*Abstracted from "The Influence of Alloying Elements on the High-Temperature Strength of Chromium-Nickel Austenite", by A. M. Borzdyka, *Doklady Akad. Nauk S.S.S.R.*, Vol. 63, 1949, p. 265-267. (In Russian.)



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Stress Relief of Austenitic Steels*

STEELS of the 18-8 type, as well as some other alloys used at high temperatures, must be quenched from a sufficiently high temperature to obtain maximum homogenization. This seems to set up huge residual stresses.

In their experiments the authors used disks 20 mm. thick and 170 mm. O.D., bored with a round concentric hole of 70 mm. diameter. Additional disks 60 mm. thick formed end plates for a stack of twenty experimental disks, and a bolt passing through these end plates and secured by a nut kept the whole stack together. In this shape the stack was heated to 1920° F. (duration not given) and quenched in cold water. Obviously the quenching proceeded from the outer surface and both radial and tangential stresses should set in.

Of the disks so treated, three (No. 4, 11, 18) were investigated for their tangential and radial stresses using the method of G. Sachs and the formula he developed for that purpose. In each of the three disks, 12 stress points were established and the stress diagrams showed that the distribution of stress was quite uniform: from about 34,000 psi. plus to 34,000 psi. minus in tangential stress (compression on the outside) and about 10,000 psi. of radial tensile stress at the middle of each disk.

All other disks except No. 1, which was left over for control purposes, were heat treated in the range from 1110 to 1560° F. It was found that at 1110° F. about 50% of the residual stress could be eliminated, but the results depended on the time factor. At 1200° F. the effects of the duration of heating were already quite small. At 1380° F. about 70% of the stress was eliminated and at 1470° F. the elimination was technically complete in less than 1 hr.

From the remaining parts of the treated disks, tensile test bars were made (size not mentioned). None of the treatments changed the ten-

(Continued on page 588)

*Abstracted from "The Effects of Temperature and Duration of Heating on the Reduction of Residual Stress in Austenitic Steels", by L. A. Glikman and V. P. Tekht, *Kotloturbostroenie*, 1948, No. 2, p. 12-16. (In Russian.)

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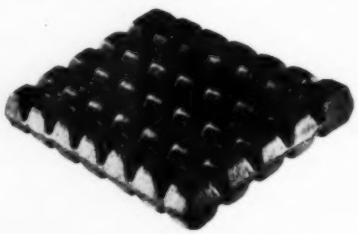

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Stress Relief

(Starts on page 586)

sile strength, yield, elongation, reduction of area, or hardness. But the notched-bar impact values were highest as quenched (16 to 19), second best as treated at 1560° F. (15 to 17) and only 12 to 14 when treated at the lower temperatures.

The work done by the authors was obviously quite immense, and their diagrams are rather neat—perhaps too neat. But their drilling operations had to stop about 16 mm. inward from the outer edge; that is, 30% of the material was left over and, since the stresses are measured only in relation to the dimensions of the remaining part, true residual stresses could hardly be known, a drawback of all stress measurements made by the Heyn-Sachs method.

A question might be raised as to whether the stress elimination is really important or worth while. Test bars taken from the disk that was not stress relieved were at least as good in every respect tested (better in notch-impact). The presence of a residual pressure of 34,000 psi. on the outer surface is more likely to be an advantage than a drawback. The residual tensile stress of 34,000 psi. could be taken care of by proper design; additional experiments would be needed to establish the values of the yield strength in the tension-strained zones.

The authors state that the results should be valid for all Cr-Ni steels, but one would hardly expect the manufacturers to accept that dictum without further testing. M. G. C.

Ceramic Turbine Blades*

SEARCH for ceramic bodies that could be used for load-carrying details in ultra-high temperature equipment was undertaken in 1944 by the National Bureau of Standards. Preliminary tests of commercial bodies obtained from leading ceramic concerns proved inferior for this purpose to bodies formulated at the Bureau, when judged

(Continued on page 592)

*From "Strength and Creep Characteristics of Ceramic Bodies at Elevated Temperatures", by M. D. Burdick, R. E. Moreland, and R. F. Geller, Technical Note No. 1561, National Advisory Committee for Aeronautics.

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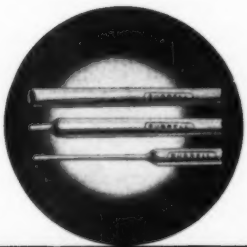

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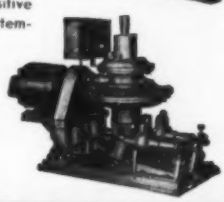

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(Starts on page 588)

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Fourth, the specimen was held at given temperature and load until failure — a regular "creep" test.

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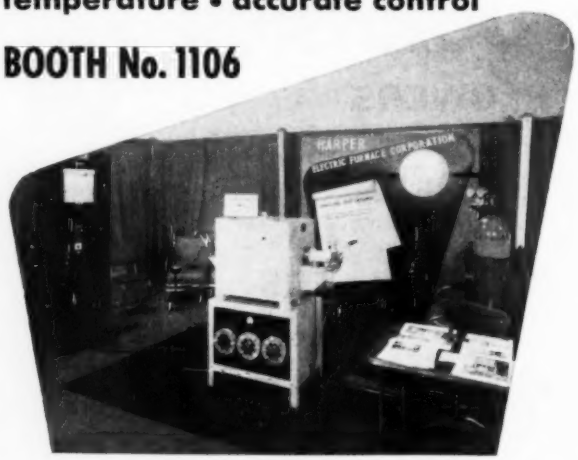

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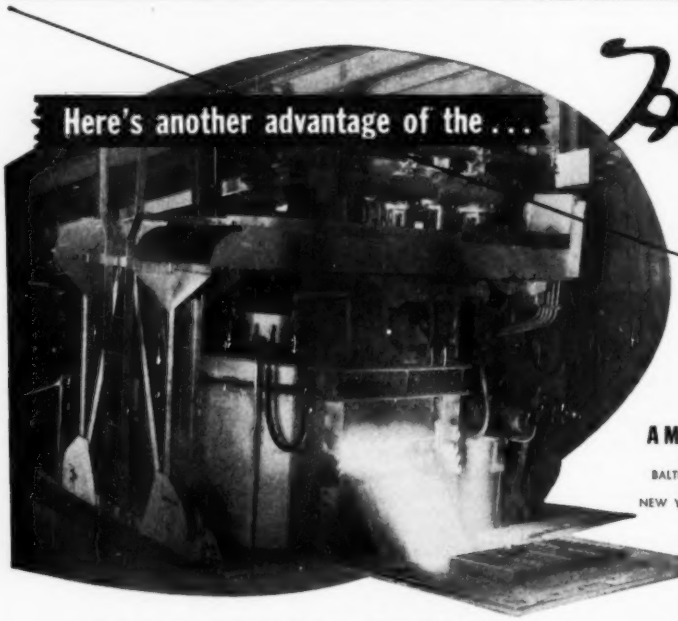

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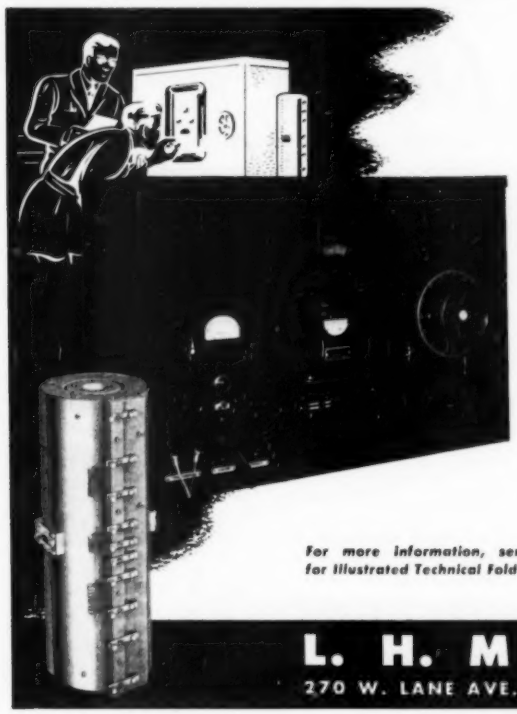

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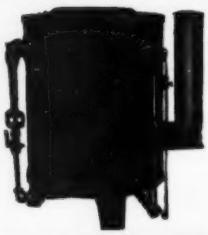

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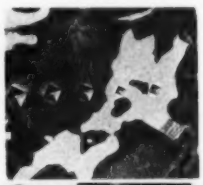

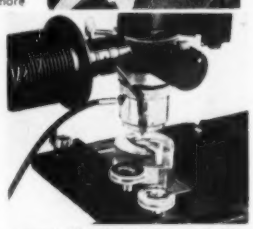

(Above) Micro-indentations in carbide and pearlite areas of cast iron specimen. Magnification 1000. (Below) MH Hardness Indenter mounted on table microscope.

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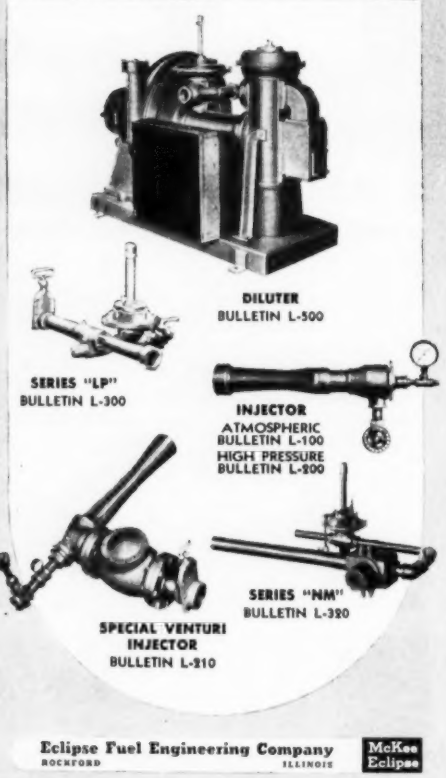

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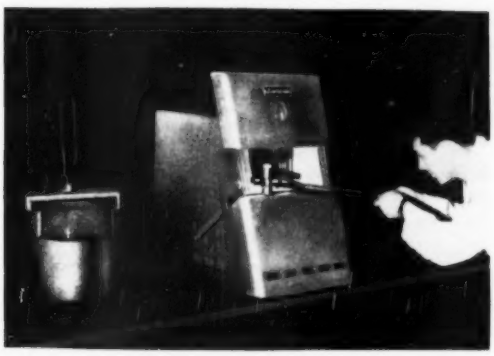

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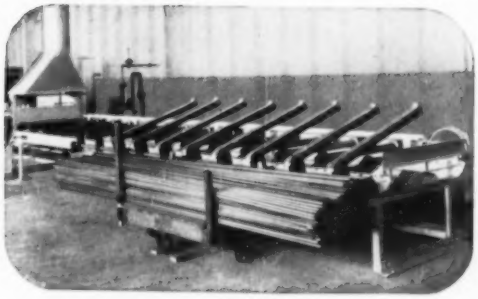

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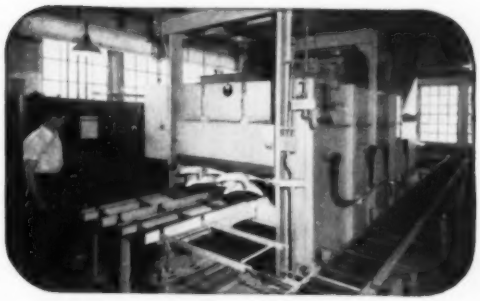

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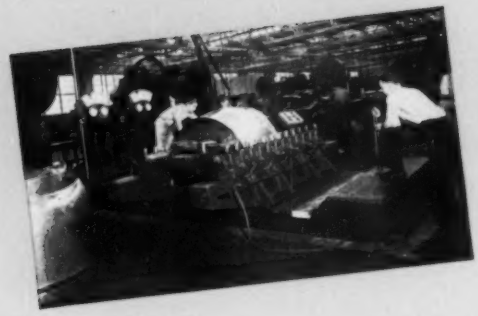

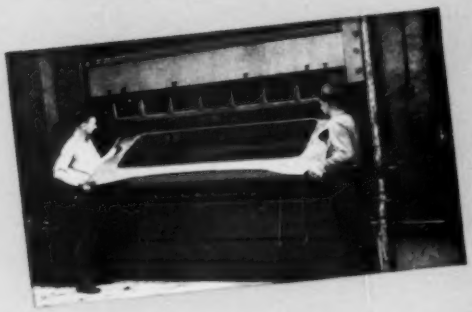

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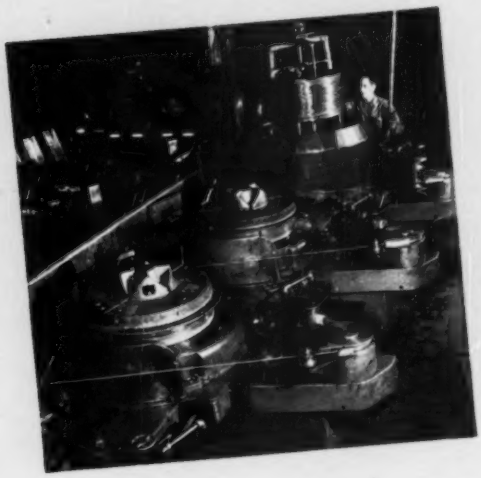

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